

Eleven new species and one new record of black flies (Diptera: Simuliidae) from Bhutan

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Abstract: Eleven new species and one new record of black flies (Diptera: Simuliidae) are described on the basis of reared adult, pupal and/or larval specimens collected from Bhutan. They are assigned to four subgenera within the genus *Simulium*: *Gomphostilbia* (two new species), *Montisimulium* (two new species and one new record), *Nevermannia* (three new species of which one belongs to the *feuerborni* species-group and two to the *vernum* species-group), and *Simulium* (four new species of which two belong to the *multistriatum* species-group and two to the *tuberosum* species-group). This study has increased the total number of simuliid species recorded from Bhutan from six to 18.

Key words: black fly, Simuliidae, *Simulium*, Bhutan, new species

The fauna of black flies (Diptera: Simuliidae) in Bhutan has been poorly studied. Only six species have been recorded to date: i.e., *Simulium* (*Nevermannia*) *aureohirtum* Brunetti, S. (*Simulium*) *biforaminiferum* Datta, S. (S.) *dentatum* Puri, S. (S.) *griseus* Brunetti, S. (S.) *indicum* Becher, and S. (S.) *striatum* Brunetti (Lewis, 1974; Datta, 1991).

From July to September 2007, one of us (P. S.) carried out a survey on the aquatic stages of black flies in 17 streams located at various altitudes from 218 m up to 3,720 m in Bhutan, and obtained 14 species consisting of two known species (S. (N.) *aureohirtum* and S. (S.) *indicum*), 11 new species and one new record. In this paper, all these new species and record are described on the basis of the reared adult, pupal and/or larval specimens.

The terms for morphological features and the definitions of subgenera of the genus *Simulium* and species-groups under certain subgenera used here follow those of Takaoka (2003). Holotype and para-

type specimens of the new species, all of which are preserved in 80% ethanol, are deposited at the Department of Infectious Disease Control, Oita University.

Simulium (*Gomphostilbia*) *bhutanense* Takaoka and Somboon sp. nov.

DESCRIPTION. Female. Body length 2.3–2.4 mm. **Head.** Slightly narrower than width of thorax. Frons brownish-black, not shiny, grayish-white pruinose, densely covered with yellowish-white recumbent short hairs interspersed with few dark simple longer hairs along each lateral margin; frontal ratio 1.35–1.61 : 1.00 : 1.66–1.76; frons-head ratio 1.00 : 4.19–4.34. Fronto-ocular area (Fig. 1A) well developed, narrow, directed dorsolaterally. Clypeus brownish-black, grayish-white pruinose, densely covered with yellowish-white recumbent short hairs interspersed with several dark longer hairs on each side of lower 1/2. Labrum 0.66 times as long as clypeus. Antenna composed of scape, pedicel and 9 flagellomeres, light to medium brown except scape, pedicel, and basal 1/4 to all of 1st flagellomere

whitish-yellow when viewed dorsally (1st flagellomere mostly whitish-yellow when viewed ventrally). Maxillary palp composed of 5 segments, light to medium brown, proportional lengths of 3rd, 4th, and 5th segments 1.00:1.21:2.35; 3rd segment (Fig. 1B) somewhat swollen; sensory vesicle (Fig. 1B) elongate, 0.50–0.53 times as long as 3rd segment, with medium-sized opening apically. Maxillary lacinia with 13 or 14 inner and 16–18 outer teeth. Mandible with 28–30 inner and 11 or 12 outer teeth. Cibarium (Fig. 1C) medially forming rectangular sclerotized plate folded forward from posterior margin, with strongly sclerotized medial longitudinal ridge having notched apex on posterior wall. **Thorax.** Scutum dark brown to brownish-black (except anterior calli light brown), shiny, grayish-white pruinose with 3 faint non-pruinose longitudinal vittae (1 medial and 2 submedial) when illuminated at certain angle of light, densely covered with yellowish-white scale-like recumbent hairs and without dark brown upright hairs on prescutellar area. Scutellum medium to dark brown, covered with yellowish-white short hairs and dark brown long upright hairs along posterior margin. Postnotum dark brown, shiny, grayish-white pruinose when illuminated at certain angle of light, and bare. Pleural membrane bare. Katepisternum dark brown, longer than deep, shiny, grayish-white pruinose, moderately covered with whitish-yellow hairs as well as dark hairs. **Legs.** Foreleg: coxa whitish-yellow; trochanter light brown except basal 1/2 of posterior surface whitish-yellow; femur light brown with apical cap medium brown (though extreme tip narrowly pale); tibia medium brown with extreme base yellowish-white and medial portion of outer surface widely light brown; outer surface of tibia slightly shiny when illuminated at certain angle of light; tarsus brownish-black, with moderate dorsal hair crest; basitarsus moderately dilated, 6.15 times as long as its greatest width. Midleg: coxa medium brown except posterior surface brownish-black; trochanter whitish-yellow except posterior surface light brown; femur light brown with apical cap medium brown (though extreme tip narrowly light brown); tibia whitish-yellow on base, then medium brown on rest though often somewhat lighter subbasally; tibia moderately or densely covered with whitish-yellow fine hairs on basal 2/5 of outer surface and on basal 3/5 of pos-

terior and inner surface; tarsus medium to dark brown except basal 1/2 or slightly more dark yellow to light brown. Hind leg: coxa light to medium brown; trochanter whitish-yellow; femur light to medium brown with basal extreme whitish-yellow and apical cap dark brown (though extreme tip narrowly light brown); tibia (Fig. 1D) whitish-yellow on base, then medium brown to brownish-black though often somewhat lighter submedially; tibia densely covered with whitish-yellow fine hairs on basal 3/4 of outer and posterior surface (thus tibia appearing yellowish on basal 3/4 due to this hair covering when illuminated at certain angle of light); tarsus (Fig. 1E) dark brown except basal 3/5 of basitarsus (though base medium brown) and basal 1/2 of 2nd tarsal segment whitish-yellow; basitarsus narrow, nearly parallel-sided, 6.00 times as long as wide, and 0.70 and 0.58 times as wide as greatest widths of tibia and femur, respectively; calcipala nearly as long as wide, and 0.43 times as wide as greatest width of basitarsus; pedisulcus well developed. Claw (Fig. 1F) with medium-sized basal tooth 0.31 times as long as and 0.32 times as wide as claw. **Wing.** Length 1.8–1.9 mm. Costa with dark spinules and hairs except basal portion with whitish-yellow hairs. Subcosta with dark hairs except apical 1/4–1/3 bare. Hair tuft on stem vein mostly medium brown. Basal portion of radius fully haired; R_1 with dark spinules and hairs; R_2 with hairs only. Basal cell absent. **Abdomen.** Basal scale light to medium brown, with fringe of whitish-yellow hairs. Dorsal surface of abdomen light to dark brown, moderately covered with dark short to long hairs; tergites of segments 2 and 5–9 shiny, while those of segments 3 and 4 dull; sternal plate on segment 7 undeveloped. **Genitalia.** Sternite 8 (Fig. 1G) bare medially, with 11–16 medium-long to long hairs together with few short slender hairs on each side. Ovipositor valves (Fig. 1G) triangular, with round medioposterior corners, thin, membranous, moderately covered with microsetae interspersed with 4–6 short setae; inner margins very slightly sinuous, slightly sclerotized, and moderately separated from each other. Genital fork (Fig. 1H) of usual inverted-Y form, with arms of moderate width; arm moderately folded medially and with distinct triangular projection directed posteromedially. Paraproct in ventral view (Fig. 1I) nearly as long as wide, pointed medially,

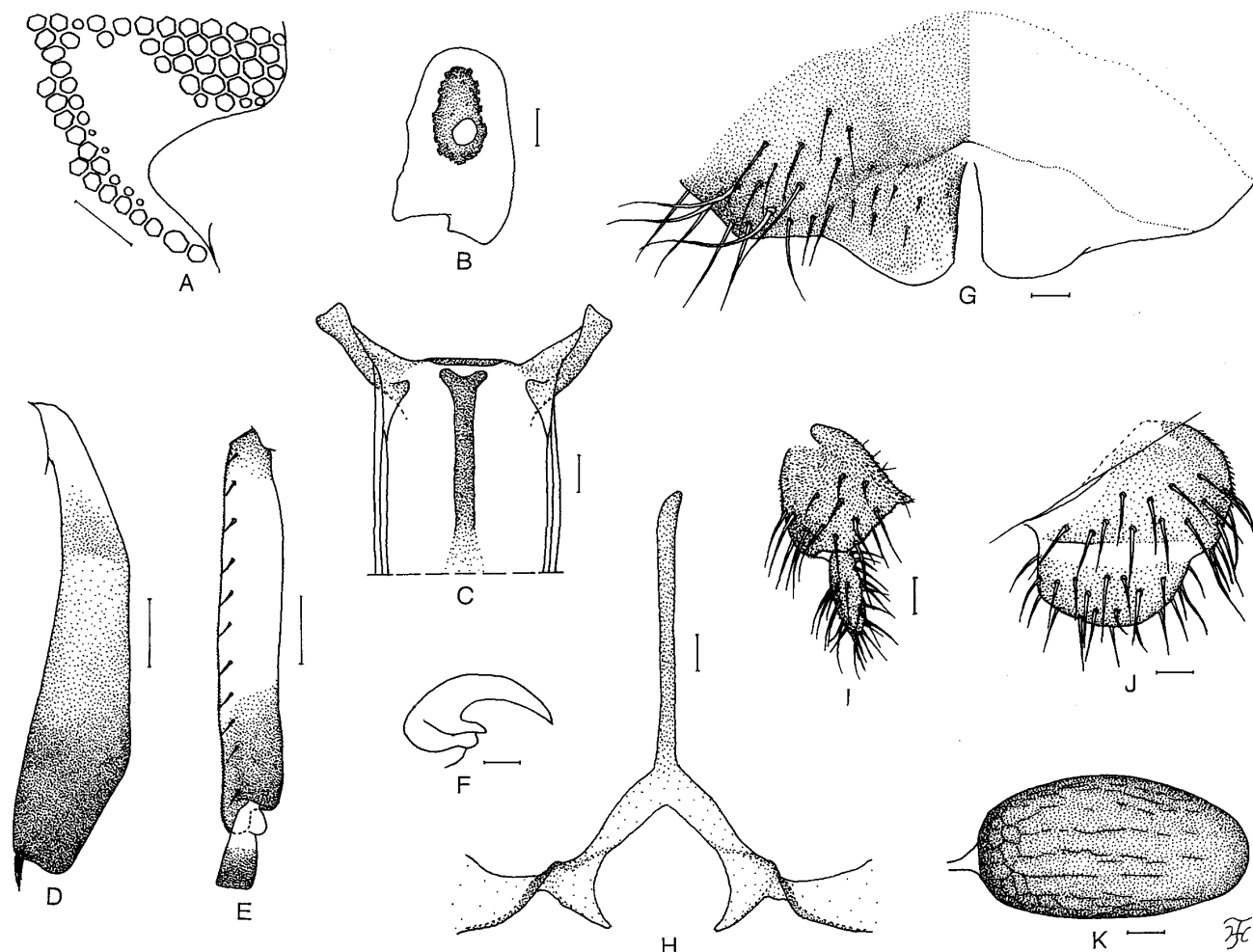


Fig. 1. Female of *Simulium (Gomphostilbia) bhutanense* sp. nov. A, fronto-ocular area (right side; front view); B, 3rd segment of maxillary palp with sensory vesicle (left side; front view); C, upper portion of cibarium; D, hind tibia (left side; outer view); E, hind basitarsus and 2nd tarsal segment (left side; outer view); F, tarsal claw; G, 8th sternite and ovipositor valves *in situ*; H, genital fork; I and J, paraproct and cercus (right side; I, ventral view; J, lateral view); K, spermatheca. Scale bars. 0.1 mm for D and E; 0.05 mm for A; 0.02 mm for B, C and G–K; 0.01 mm for F.

depressed along anteromedial margin, and with 4 sensilla on anteromedial surface; paraproct in lateral view (Fig. 1J) somewhat produced ventrally, 0.68–0.77 times as long as wide, with 18–20 medium-long to long hairs on ventral and lateral surface. Cercus in lateral view (Fig. 1J) short, rounded posteriorly, 0.45–0.51 times as long as wide. Spermatheca (Fig. 1K) ellipsoidal, 1.83–1.88 times as long as its greatest width, well sclerotized except duct and juncture with duct unsclerotized, and with many fissures on surface; internal setae absent; both accessory ducts slender, slightly larger in diameter than major one.

Male, Pupa and Mature larva. Unknown.

TYPE SPECIMENS. Holotype female reared from a pupa collected from an irri-

gation channel (width 0.8 m, depth 0.2 m, water temperature 29.6°C, shaded, altitude 218 m; 26°52' 03"N, 90°31' 35"E) at Chuzargang, Gelephu, Bhutan, 3. VIII. 2007. Paratypes 5 females, same data as those of the holotype. The pupal exuviae of these type females were not available.

ECOLOGICAL NOTES. The pupae of this new species were collected from grasses in the water of a moderately flowing irrigation channel, together with *S. (G.) chuzargangense* sp. nov.

ETYMOLOGY. The species name *bhutanense* refers to the country, Bhutan.

REMARKS. According to the key (Takaoka, 2003), *S. (G.) bhutanense* sp. nov. is assigned to the *batoense* or *ceylonicum* species-group within the subgenus *Gomphostilbia* by having the adult female antenna with 11 segments, pleural membrane bare, katepisternum haired, female claw with a medium-sized basal tooth (Fig. 1F) and spermatheca without a sclerotized neck (Fig. 1K).

The female of this new species is most striking in that it has the claw with a medium-sized tooth (Fig. 1F). There are only two known *Gomphostilbia* species that have such a medium-sized tooth on the claw, *S. (G.) tahanense* Takaoka and Davies, described from Peninsular Malaysia (Takaoka and Davies, 1995), and *S. (G.) mogii* Takaoka, described from Sulawesi, Indonesia (Takaoka, 2003), although their teeth (0.43 and 0.42 times as long as the claw, respectively) are much longer than that of *S. (G.) bhutanense*.

***Simulium (Gomphostilbia) chuzargangense*
Takaoka and Somboon sp. nov.**

DESCRIPTION. Female. Body length 2.0 mm. **Head.** Slightly narrower than width of thorax. Frons brownish-black, shiny when illuminated at a certain angle of light, grayish-white pruinose, moderately covered with yellowish-white scale-like short hairs though medial longitudinal area narrowly bare on upper 1/2; frontal ratio 1.57 : 1.00 : 2.36; frons-head ratio 1.00 : 5.18. Fronto-ocular area (Fig. 2A) well developed, narrow, directed dorsolaterally. Clypeus brownish-black, shiny when illuminated at certain angle of light, grayish-white pruinose, densely covered with yellowish-white recumbent short hairs interspersed with several dark longer hairs on each side of lower 1/2. Labrum 0.62 times as long as clypeus. Antenna composed of scape, pedicel and 9 flagellomeres, medium brown except scape, pedicel, and basal 1/3 of 1st flagellomere yellow when viewed dorsally (1st flagellomere mostly whitish-yellow when viewed ventrally). Maxillary palp composed of 5 segments, light to medium brown except segments 1 and 2 yellowish, proportional lengths of 3rd, 4th, and 5th segments 1.00 : 1.06 : 2.44; 3rd segment

(Fig. 2B) somewhat swollen; sensory vesicle (Fig. 2B) elongate, 0.38 times as long as 3rd segment, with small or medium-sized opening near apex. Maxillary lacinia with 8–10 inner and 11 outer teeth. Mandible with 20 inner and 8 outer teeth. Cibarium (Fig. 2C) medially forming small round sclerotized plate folded forward from posterior margin, with strongly sclerotized medial longitudinal ridge on posterior wall. **Thorax.** Scutum dark brown to brownish-black (except anterior calli light brown) with faint dark longitudinal vittae (1 medial and 2 submedial), shiny, grayish-white pruinose when illuminated at certain angle of light, densely covered with yellowish-white and dark brown recumbent hairs and without dark brown upright hairs on prescutellar area. Scutellum medium to dark brown, covered with light brown short hairs (copper-colored in light) and dark brown long upright hairs along posterior margin. Postnotum dark brown, shiny, grayish-white pruinose when illuminated at certain angle of light, and bare. Pleural membrane bare. Katepisternum dark brown, longer than deep, shiny, grayish-white pruinose, moderately covered with whitish-yellow hairs as well as dark hairs. **Legs** (Color appearing incomplete). Foreleg: coxa whitish-yellow; trochanter light brown except basal 1/2 yellow; femur grayish-yellow to light brown with apical cap medium brown; tibia medium brown with extreme base narrowly light brown and medial portion of outer surface widely light brown; outer surface of tibia brightly shiny when illuminated at certain angle of light; tarsus dark brown, with moderate dorsal hair crest; basitarsus moderately dilated, 5.52 times as long as its greatest width. Midleg: coxa medium brown except posterior surface brownish-black; trochanter whitish-yellow except posterior surface light brown; femur grayish-yellow with apical cap medium brown; tibia whitish-yellow to light brown on basal 3/4, with small light brown spot sub-basally, then medium brown on apical 1/4 (though its border not well defined); tibia moderately or densely covered with whitish-yellow fine hairs on basal 2/5 of outer surface and on basal 3/5 of posterior and inner surface; tarsus medium brown except basal 1/2 grayish-yellow to light brown. Hind leg: coxa medium brown; trochanter yellow; femur grayish-yellow with basal extreme yellow and apical cap medium brown (though extreme tip nar-

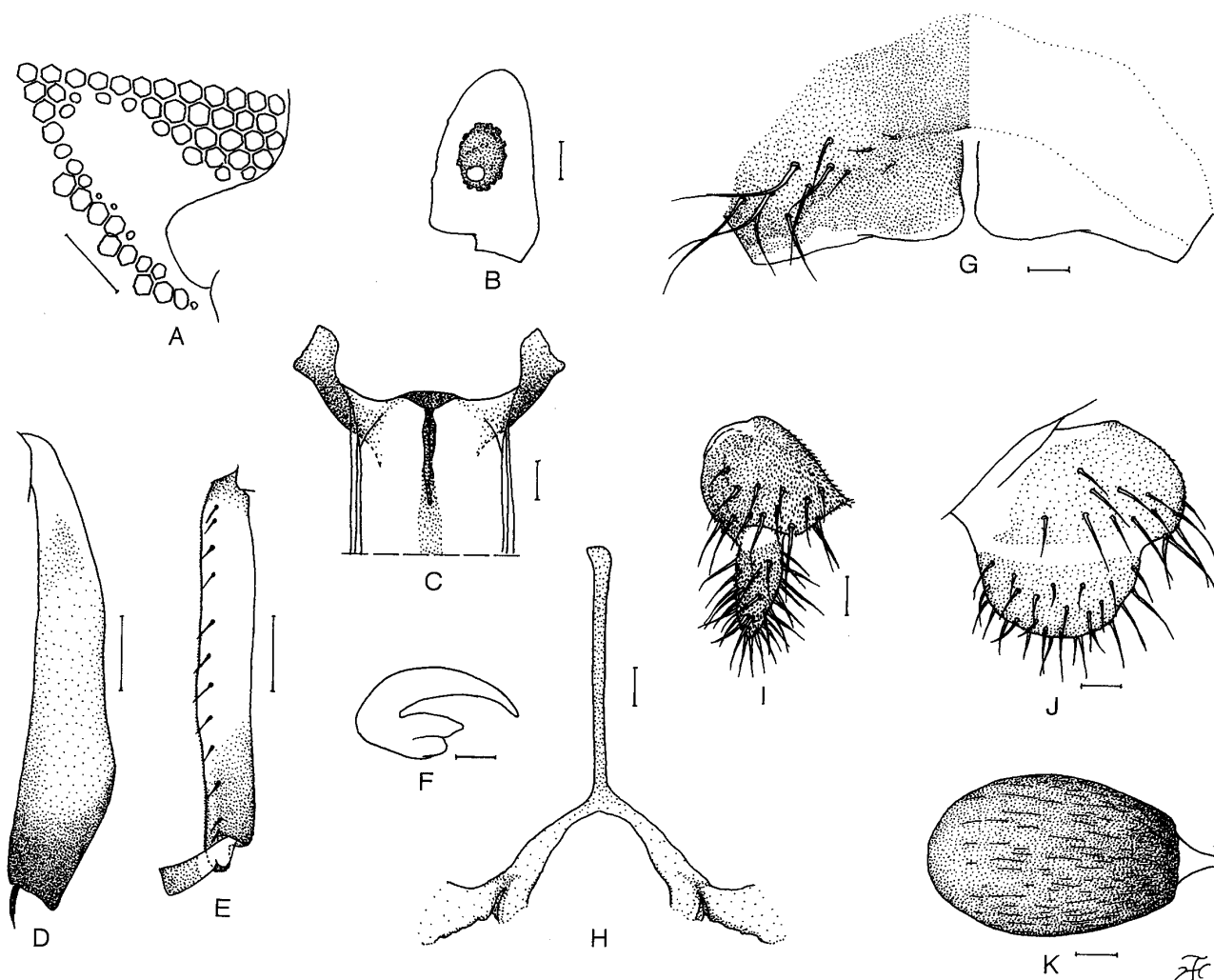


Fig. 2. Female of *Simulium* (*Gomphostilbia*) *chuzargangense* sp. nov. A, fronto-ocular area (right side; front view); B, 3rd segment of maxillary palp with sensory vesicle (left side; front view); C, upper portion of cibarium; D, hind tibia (left side; outer view); E, hind basitarsus and 2nd tarsal segment (left side; outer view); F, tarsal claw; G, 8th sternite and ovipositor valves *in situ*; H, genital fork; I and J, paraproct and cercus (right side; I, ventral view; J, lateral view); K, spermatheca. Scale bars. 0.1 mm for D and E; 0.05 mm for A; 0.02 mm for B, C and G–K; 0.01 mm for F.

rowly light brown); tibia (Fig. 2D) yellowish on base, then grayish-yellow to light brown, with apical cap medium brown, and with subbasal light to medium brown spot on each side; tibia moderately covered with whitish-yellow fine hairs on basal 3/4 of outer and posterior surface (thus tibia appearing yellowish on basal 3/4 due to this hair-covering when illuminated at certain angle of light); tarsus (Fig. 2E) medium brown except basal 3/5 of basitarsus (though base light brown) and basal 1/2 of 2nd tarsal segment whitish-yellow; basitarsus narrow, nearly parallel-sided, 7.09 times as long as wide, and 0.58 and 0.50 times as wide as greatest widths of tibia and femur, respectively; calcipala 1.1 times as long as its width at base, and 0.50 times as wide as greatest width

of basitarsus; pedisulcus well developed. Claw (Fig. 2F) with large basal tooth 0.52 times as long as claw. **Wing.** Length 1.8 mm. Costa with dark spinules and hairs except basal portion intermixed with whitish-yellow hairs. Subcosta bare on right side and with 1 hair on left side. Hair tuft on stem vein medium brown. Basal portion of radius fully haired; R_1 with dark spinules and hairs; R_2 with hairs only. Basal cell absent. **Abdomen.** Basal scale medium brown, with fringe of whitish-yellow hairs. Dorsal surface of abdomen medium brown except middle 1/3 of tergite 2 yellow, moderately covered with dark short to long hairs; tergites of segments 2 and 6–9 shiny, while those of segments 3–5 dull; sternal plate on segment 7 undeveloped. **Genitalia.**

Sternite 8 (Fig. 2G) bare medially, with 8–10 medium-long to long hairs together with few short slender hairs on each side. Ovipositor valves (Fig. 2G) triangular, with round medioposterior corners, thin, membranous, moderately covered with microsetae intermixed with 1 short seta; inner margins very slightly sinuous, slightly sclerotized, and moderately separated from each other. Genital fork (Fig. 2H) of usual inverted-Y form, with arms of moderate width; arm moderately folded medially. Paraproct in ventral view (Fig. 2I) nearly as long as wide, pointed medially, depressed along anteromedial margin, and with 6–8 sensilla on anteromedial surface; paraproct in lateral view (Fig. 2J) somewhat produced ventrally, 0.66 times as long as wide, with 13–15 medium-long to long hairs on ventral and lateral surface. Cercus in lateral view (Fig. 2J) short, rounded posteriorly, 0.55 times as long as wide. Spermatheca (Fig. 2K) ellipsoidal, 1.56 times as long as its greatest width, well sclerotized except duct and juncture with duct unsclerotized, and with many fissures on surface; internal setae absent; both accessory ducts slender, subequal in diameter to major one.

Male, Pupa and Mature larva. Unknown.

TYPE SPECIMEN. Holotype female reared from a pupa collected from the same irrigation channel as noted under *S. (G.) bhutanense* sp. nov. The pupal exuviae of this female was not available.

ECOLOGICAL NOTE. No biological or ecological aspects of this new species are known. An associated species was *S. (G.) bhutanense* sp. nov.

ETYMOLOGY. The species name *chuzargangense* refers to the locality, Chuzargang, where this new species was collected.

REMARKS. *Simulium (G.) chuzargangense* sp. nov. is assigned to the *batoense* or *ceylonicum* species-group within the subgenus *Gomphostilbia* by having the adult female antenna with 11 segments, pleural membrane bare, katapisternum haired, female claw with a large basal tooth (Fig.

2F) and spermatheca without a sclerotized neck (Fig. 2K).

The female of this new species is most remarkable in that it has the subcosta which bears no hair or only one hair, a character very rarely found in the *batoense* species-group of the subgenus *Gomphostilbia*, e.g., *S. (G.) binuanense* Takaoka and Tenedero, described from Palawan, the Philippines (Takaoka and Tenedero, 2008), *S. (G.) kolakaense* Takaoka, and *S. (G.) singgihi* Takaoka, both described from Sulawesi, Indonesia (Takaoka, 2003). However, the medium-long sensory vesicle (Fig. 2B) separates this new species from both *S. (G.) binuanense* and *S. (G.) singgihi*, which have the longer sensory vesicle (0.56 and 0.45 times as long as the third maxillary palpal segment, respectively). This new species is very similar to *S. (G.) kolakaense* in many features but is barely distinguished from the latter species by the difference in several features including the relative width of the head against the greatest width of the frons (5.18 versus 5.51), the relative length of the fore basitarsus against its greatest width (5.52 versus 6.06) and the relative length of the calcipala against its basal width (1.10 versus 1.48).

There is a possibility that this new species, as well as *S. (G.) bhutanense* sp. nov., is the female of either *S. (G.) litoreum* Datta, *S. (G.) unum* Datta or *S. (G.) fidum* Datta, all recorded from lowlands of Assam, because all these known species were described only based on the male, pupa and/or larva, and their females remain unknown (Datta, 1975).

Simulium (Montisimulium) dattai Takaoka and Somboon sp. nov.

Simulium (Eusimulium) sp. B Datta *et al.*, 1975: 95–96 (pupa).

DESCRIPTION. Mature larva. Body length 6.8–7.0 mm. Body grayish. Cephalic apotome light to dark yellow, with well-defined positive head-spots; lateral surface of head capsule light

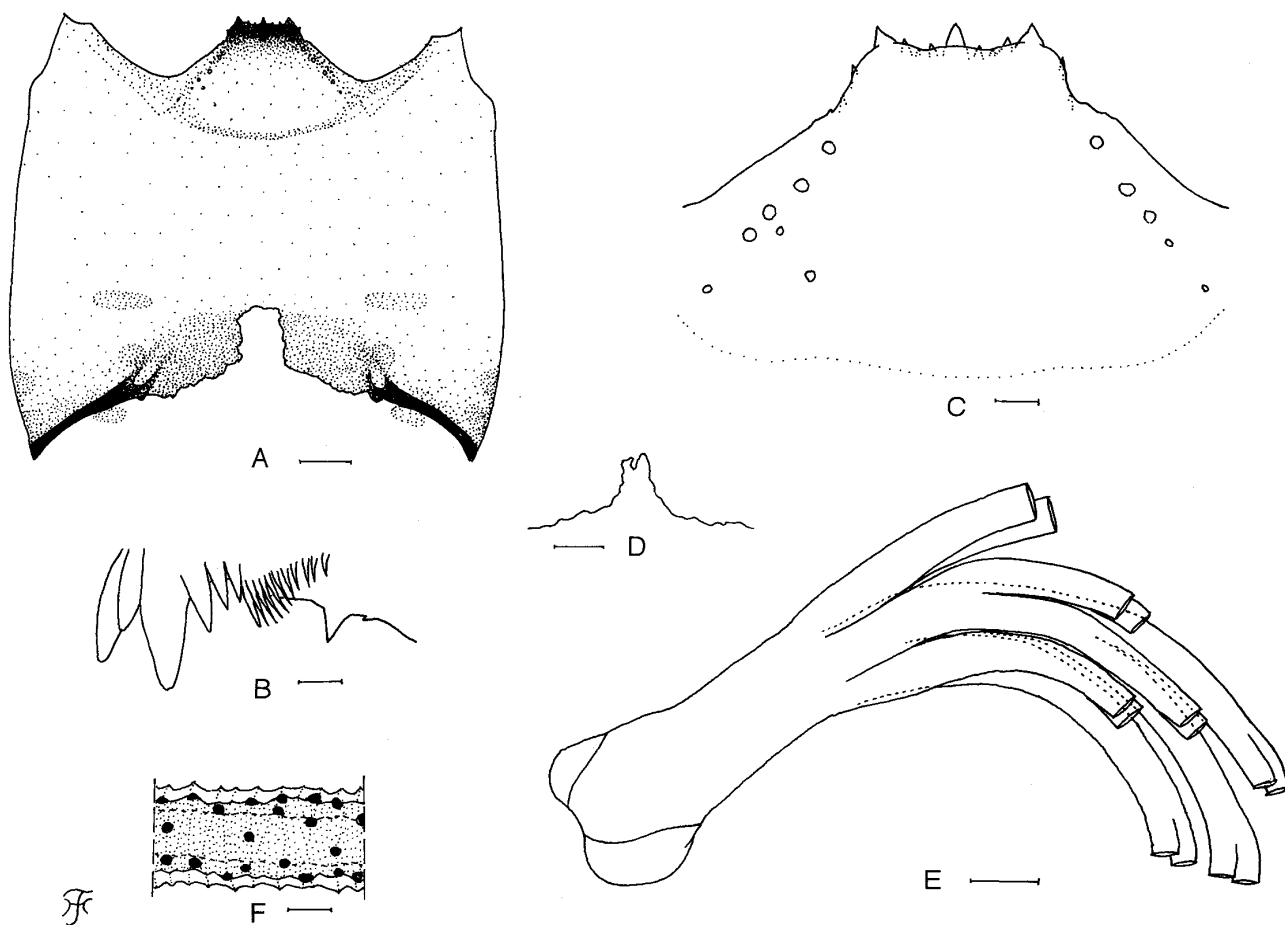


Fig. 3. Mature larva of *Simulium* (*Montisimulium*) *dattai* sp. nov. A, head capsule showing postgenal cleft (ventral view); B, mandible; C, hypostoma; D, postgenal cleft of M-shaped; E, basal portion of pharate pupal gill (right side, outer view); F, part of gill filament showing sharply-defined annular ridges and furrows and black tubercles scattered inside the outer cuticular layer. Scale bars. 0.1 mm for A, D and E; 0.02 mm for C; 0.01 mm for B and F.

to dark yellow except eye-spot region clear yellowish-white; eyebrow dark and distinct; 5 spots (2 large and 3 small) near posterior margin and 1 small spot just below eye-spot region dark brown and distinct; ventral surface of head capsule (Fig. 3A) light to dark yellow, with medium brown basal area on each side of postgenal cleft; horizontal and round spots on each side of postgenal cleft medium brown and distinct. Cervical sclerites composed of 2 small light yellow elliptical pieces, not fused to occiput, very widely separated medially from each other. Antenna consisting of 3 segments and apical sensillum, much longer than stem of labral fan; proportional lengths of 1st, 2nd, and 3rd segments 1.00:1.04–1.11:0.82–0.84; all segments light yellow; segment 2 of 1 larva without secondary annulations but that of another larva appearing to have 1 faint secondary annulation medially. Labral fan with 30 main rays. Mandible (Fig. 3B) with mandibular

serrations consisting of 2 teeth (1 large, 1 small); large tooth at obtuse angle to mandible on apical side; comb-teeth composed of 3 teeth, of which 1st tooth longest, 2nd tooth slightly longer than 3rd one; supernumerary serrations absent. Hypostoma (Fig. 3C) with 9 apical teeth in row; median and corner teeth well developed; median tooth of 3 intermediate teeth on each side smallest; lateral margin almost smooth; 3 or 4 hypostomal bristles (excluding 2 or 3 short slender setae) per side, lying slightly divergent posteriorly from lateral margin. Postgenal cleft (Fig. 3A, D) small, quadrate or M-shaped, 0.29–0.34 times as long as postgenal bridge. Pharate pupal gill (Fig. 3E) with 14 thread-like filaments arranged as 2 + (2 + 2) + [(2 + 2) + 2] + 2 filaments arising from medium-long common basal stalk; each filament with transverse ridges and numerous brownish-black to black small tubercles in outer cuticular layer of surface (Fig. 3F). Abdominal

cuticle bare except both sides of anal sclerite densely covered with simple colorless setae, and area just above ventral papilla on each side of segment 8 sparsely or moderately covered with simple colorless setae. Rectal scales present. Rectal papilla compound, each of 3 lobes with 10–13 finger-like secondary lobules. Anal sclerite X-shaped, with anterior arms nearly as long as posterior ones; sensilla absent on and just posterior to basal juncture area; accessory sclerite absent. Ventral papilla present. Posterior circlet with 72–78 rows of up to 16 hooklets per row.

Female and Male. Unknown.

TYPE SPECIMENS. Holotype mature larva, collected from a small stream (width 30 cm, depth about 5 cm, water temperature 18.5°C, exposed to sun, altitude 2,292 m; 27°16'05"N, 91°18'27"E) moderately flowing in a densely forested area, Korila, Mongar, Bhutan, 30. VIII. 2007. Paratype: 1 mature larva, same data and date as those of holotype.

ECOLOGICAL NOTES. The two mature larvae of this new species were collected from a stalk of trailing grass and a fallen leaf of pine tree in the water, together with *S. (M.) nemorivagum* Datta and *S. (N.) mongarensis* sp. nov. and the mosquito larvae of *Anopheles bengalensis* Puri, *An. baileyi* Edwards and *An. lindesayi* Giles.

DISTRIBUTION. Bhutan (**New record**) and India.

ETYMOLOGY. The species name *dattai* is in honor of Dr. M. Datta, Zoological Survey of India, Calcutta, India, in recognition of his great contribution on the taxonomy and ecology of the Simuliidae in India.

REMARKS. This new species is assigned to the subgenus *Montisimulium* in having the 14 gill filaments with many black minute tubercles in the outer cuticular layer of the surface (Fig. 3F), as well as a small postgenal cleft (Fig. 3A, D). The larva of *S. (M.) dattai* sp. nov. is

characterized by the pharate pupal gill with 14 thread-like filaments arranged as $2 + (2 + 2) + [(2 + 2) + 2] + 2$ filaments from dorsal to ventral, arising from a common basal stalk of moderate length (Fig. 3E) and a small quadrate or M-shaped postgenal cleft (Fig. 3A, D). The arrangement of the 14 gill filaments of the present specimens is essentially identical to that of *S. (M.)* sp. B, reported from a pupa collected in Darjeeling, northern India (Datta *et al.*, 1975), although branching points in the present specimens are all more proximal than those in *S. (M.)* sp. B.

There are four named species of *Montisimulium* reported from central Asia of the former USSR, which have the pupal gill with 14 filaments: *S. (M.) assadovi* (Djafarov), *S. (M.) litshekense* (Rubtsov), *S. (M.) quattuordecimfilum* (Rubtsov) and *S. (M.) quattuordecimfiliatum* Rubtsov (Yankovsky, 2002). The arrangements of the gill filaments of these four known species differ from that of *S. (M.) dattai* sp. nov., and the larval postgenal clefts are all very small and vestigial, differing from that of *S. (M.) dattai* sp. nov. *Simulium (M.) tibetense* Deng, Xue, Zhang and Chen from Tibet has 14 pupal gill filaments and a small subquadrate postgenal cleft (Deng *et al.*, 1994) but differs in the arrangement of the pupal gill filaments (i.e., $2 + 6 + 2 + 4$ filaments from dorsal to ventral) from *S. (M.) dattai* sp. nov. In addition, *S. (M.)* sp. C reported from a pupa collected from Darjeeling, northern India by Datta *et al.* (1975) has the gill with 14 filaments, but is easily distinguished from *S. (M.) dattai* sp. nov. by the very long common basal stalk, similar to that of the following new species.

***Simulium (Montisimulium) taktsangense*
Takaoka and Somboon sp. nov.**

DESCRIPTION. Mature larva. Body length 7.8 mm. Body light grayish. Cephalic apotome light to medium yellow, with well-defined dark head-spots; lateral surface of head capsule medium yellow except eye-spot region clear

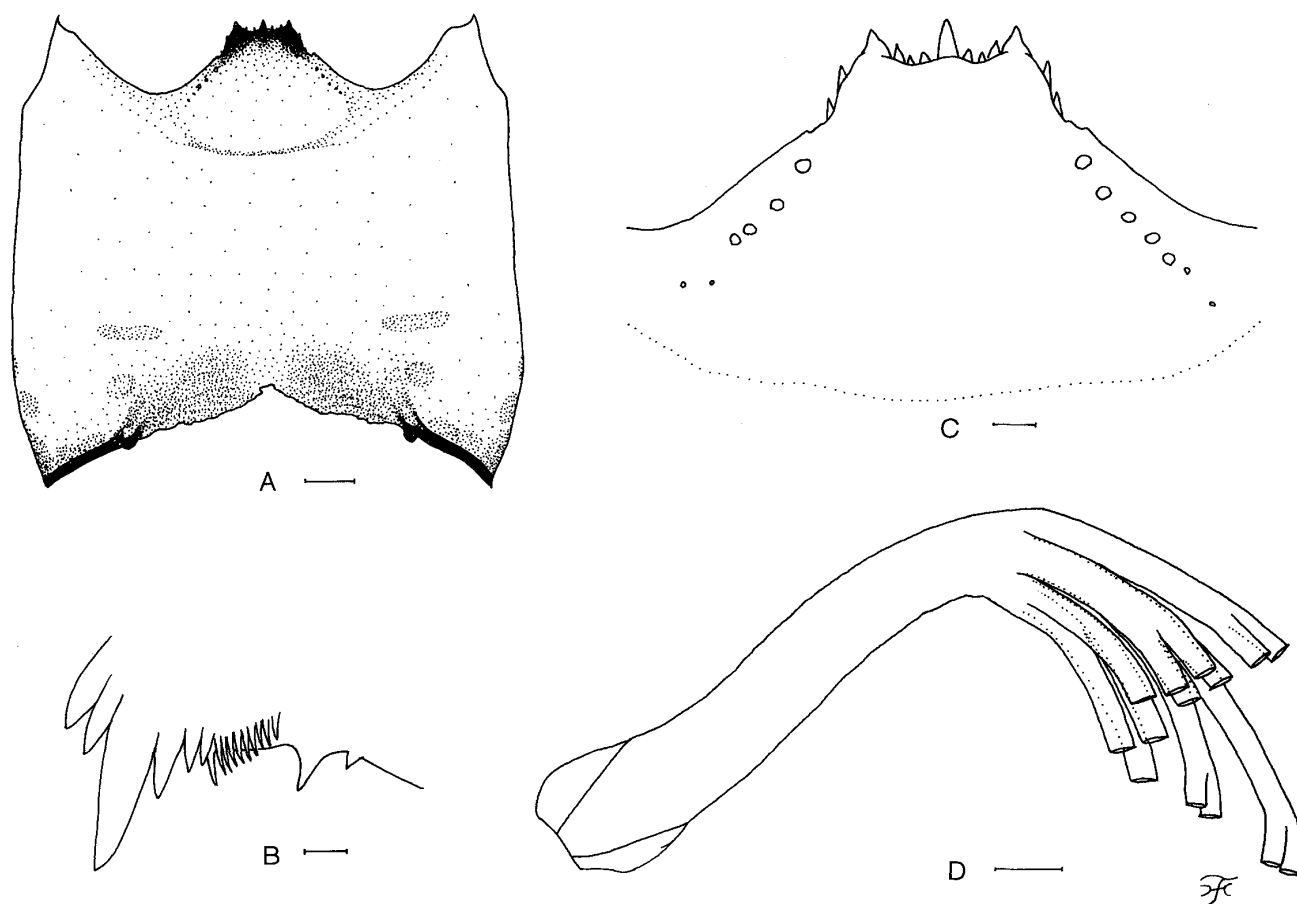


Fig. 4. Mature larva of *Simulium* (*Montisimulium*) *taksangense* sp. nov. A, head capsule showing postgenal cleft (ventral view); B, mandible; C, hypostoma; D, basal portion of pharate pupal gill (right side, outer view). Scale bars. 0.1 mm for A and D; 0.02 mm for C; 0.01 mm for B.

yellowish-white; eyebrow dark and distinct; 5 spots (2 large and 3 small) near posterior margin and 1 small spot just below eye-spot region dark brown and distinct; ventral surface of head capsule (Fig. 4A) dark yellow, with medium brown basal area on each side of postgenal cleft; horizontal and round spots on each side of postgenal cleft medium brown and distinct. Cervical sclerites composed of 2 small medium brown elliptical pieces, not fused to occiput, very widely separated medially from each other. Antenna consisting of 3 segments and apical sensillum, much longer than stem of labral fan; proportional lengths of 1st, 2nd, and 3rd segments 1.00 : 0.91 : 0.72; basal portion of 1st segment light brown and whole of 3rd segment light yellow; 2nd segment almost pale, without secondary annulations. Labral fan with 24 main rays. Mandible (Fig. 4B) with mandibular serrations consisting of 2 teeth (1 large, 1 small); large tooth at right angle to mandible on apical side; comb-teeth composed of 3 teeth, of which 1st tooth longest, 2nd tooth

slightly longer than 3rd one; supernumerary serrations absent. Hypostoma (Fig. 4C) with 9 apical teeth in row; median and corner teeth well developed; median tooth of 3 intermediate teeth on each side smallest; lateral margin almost smooth; 4 or 5 hypostomal bristles (excluding 2 short slender setae) per side, lying slightly divergent posteriorly from lateral margin. Postgenal cleft (Fig. 4A) small, vestigial. Pharate pupal gill (Fig. 4D) with 14 thread-like filaments arranged as $2 + (2 + 2) + (2 + 2) + [(1 + 2) + 1]$ filaments arising from very long common basal stalk; each filament with transverse ridges and numerous brownish-black to black small tubercles in outer cuticular layer of surface. Abdominal cuticle bare except both sides of anal sclerite densely covered with simple colorless setae, and area just above ventral papilla on each side of segment 8 sparsely or moderately covered with simple colorless setae. Rectal scales present. Rectal papilla compound, each of 3 lobes with 5–7 finger-like secondary lobules. Anal sclerite X-shaped,

with anterior arms slightly shorter than posterior ones; sensilla absent on and just posterior to basal juncture area; accessory sclerite absent. Ventral papilla present. Posterior circlet with 92 rows of up to 13 hooklets per row.

Female, Male and Pupa. Unknown.

TYPE SPECIMEN. Holotype mature larva, collected from a small stream (width 30 cm, depth about 5 cm, water temperature little below 10°C, shaded, altitude 3,103 m) moderately flowing in a densely forested area below the Taktsang monastery, Paro, Bhutan, 22. IX. 2007. Other specimens examined: 2 immature larvae, same data and date as those of the holotype.

ECOLOGICAL NOTES. The larvae of this new species were collected from stalks of trailing grasses in the water, together *S. (S.) pradyai* sp. nov., *An. lindesayi* and *Culex mimeticus* Noe.

ETYMOLOGY. The species name *taktsangense* refers to the Taktsang monastery, the most famous Bhutanese monastery located in the Paro valley, western Bhutan, where this new species was collected.

REMARKS. This new species is also assigned to the subgenus *Montisimulium* by the pharate pupal gill with 14 filaments (Fig. 4D) with many black minute tubercles in the outer cuticular layer of the surface (similar to those of Fig. 3F) and a small postgenal cleft (Fig. 4A). The larva of this new species is characterized by the pharate pupal gill with 14 thread-like filaments arranged as $2 + (2 + 2) + (2 + 2) + [(1 + 2) + 1]$ filaments arising from a long common basal stalk (Fig. 4D) and a small vestigial postgenal cleft (Fig. 4A). This new species is easily distinguished from *S. (M.) dattai* sp. nov. by the very long common basal stalk of the pharate pupal gill as well as the small vestigial postgenal cleft. *Simulium (M.)* sp. C, reported on the

basis of a pupa collected in Darjeeling, India (Datta *et al.*, 1975), is the only species that has such a long common basal stalk among the *Montisimulium* species having 14 pupal gill filaments (Yankovsky, 2002; Datta *et al.*, 1975). However, the arrangement of the 14 gill filaments of *S. (M.)* sp. C, i.e., $[(2 + 1) + (2 + 1)] + [2 + (2 + 2)] + 2$ filaments from dorsal to ventral, is clearly different from that of *S. (M.) taktsangense* sp. nov.

Simulium (Montisimulium) nemorivagum Datta

Simulium (Eusimulium) nemorivagum Datta, 1973: 373–375 (male, pupa and mature larva); Datta, 1974: 457–459 (female).

Simulium (Montisimulium) nemorivagum, Datta, 1992: 47–48.

SPECIMENS EXAMINED. Two mature larvae collected from the same stream noted under the holotype of *S. (M.) dattai* sp. nov.; 2 mature larvae collected from a small stream (width 1 m, depth 10 cm, water temperature below 5°C, exposed to sun, altitude 3,720 m; 27°23'54"N, 90°59'39"E) slowly flowing in a densely forested area, near Thrimshingla, Mongar, Bhutan, 4. IX. 2007.

BIOLOGICAL NOTES. The larvae of this new species were collected from stalks of trailing grasses. The associated species were *S. (M.) dattai* sp. nov., *S. (N.) mongarensis* sp. nov., *S. (N.) thrimshinglaensis* sp. nov. and *S. (S.) pradyai* sp. nov.

DISTRIBUTION. Bhutan (**New record**), India and Pakistan.

REMARKS. The present larval specimens are also assigned to the subgenus *Montisimulium* in having the 12 gill filaments (Fig. 5E) with many black minute tubercles in the outer cuticular layer of the surface (similar to those of Fig. 3F), as well as a small postgenal cleft (Fig. 5A).

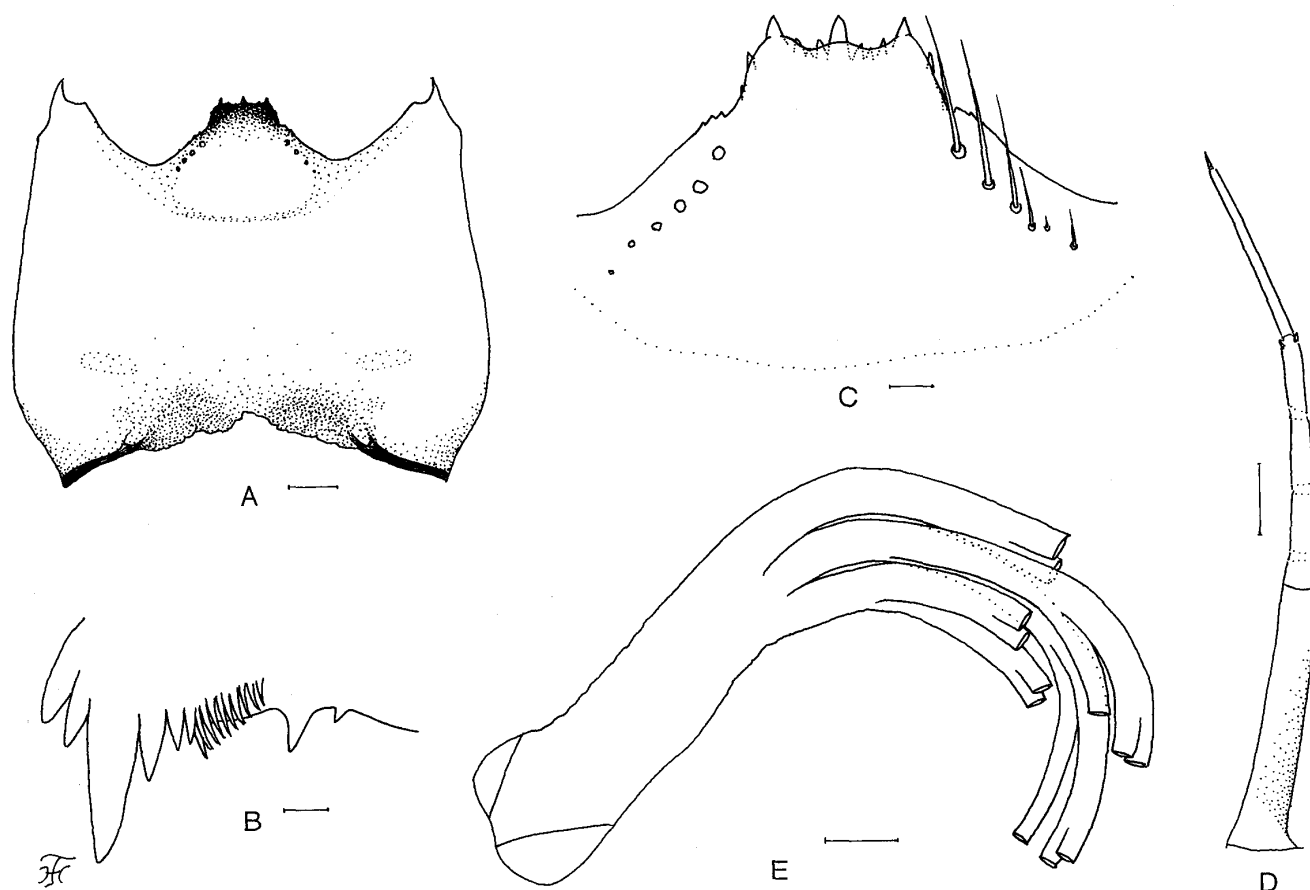


Fig. 5. Mature larva of *Simulium* (*Montisimulium*) *nemorivagum* Datta. A, head capsule showing postgenal cleft (ventral view); B, mandible; C, hypostoma; D, antenna (left side; lateral view); E, basal portion of pharate pupal gill (right side, outer view). Scale bars. 0.1 mm for A and E; 0.05 mm for D; 0.02 mm for C; 0.01 mm for B.

They are provisionally identified as *S. (M.) nemorivagum* originally described from Darjeeling, northern India (Datta, 1973) since the arrangement of the 12 filaments of the pharate pupal gill of the present specimens, $2 + [(2 + 1) + (2 + 1)] + (2 + 2)$ filaments from dorsal to ventral, arising from a common basal stalk of moderate length (Fig. 5E), as well as the mandible (Fig. 5B), is almost the same as that of *S. (M.) nemorivagum* (Datta, 1973). However, it should be noted that there are several differences in other larval features (characteristics of *S. (M.) nemorivagum* in parentheses): 1) the median tooth of the nine anterior teeth of the hypostoma is nearly as long as each corner tooth in the present specimens (Fig. 5C) (the median tooth is much shorter than each corner tooth), and 2) antenna with three faint secondary annulations on the second seg-

ment (Fig. 5D) (no secondary annulations on the second segment, probably overlooked).

***Simulium* (*Nevermannia*) *mongarensis*
Takaoka and Somboon sp. nov.**

DESCRIPTION. Male. Body length 3.7 mm. **Head.** Nearly as wide as thorax. Upper eye consisting of large facets in 18 vertical columns and 20 horizontal rows. Clypeus dark brown, not shiny, whitish-gray pruinose, moderately covered with yellow short hairs interspersed with dark long hairs. Antenna composed of scape, pedicel and 9 flagellomeres, light brown except scape, pedicel and base of 1st flagellomere yellow when viewed anteriorly, or light brown except scape, basal 1/2 of pedicel and base of 1st flagellar segment yellow when viewed posteriorly; 1st flagellomere elongate, 2.53 times as long as 2nd one. Maxillary palp medium to dark brown, com-

posed of 5 segments, proportional lengths of 3rd, 4th, and 5th segments 1.00 : 1.18 : 2.24; 3rd segment (Fig. 6A) of moderate size; sensory vesicle (Fig. 6A) small, globular or ellipsoidal, 0.14 times as long as 3rd segment. **Thorax.** Scutum dark brown (except anterolateral calli ocherous) with 2 darker submedial longitudinal vittae, shiny at certain angles of light, thinly whitish-gray pruinose except central portion widely unpruinose, with 3 unpruinose longitudinal vittae (1 medial and 2 submedial) when illuminated dorsally and viewed anterodorsally, densely covered with whitish-yellow (golden in light) recumbent hairs, and with several dark brown upright hairs on pre-scutellar area. Scutellum ocherous, with many dark upright hairs as well as whitish-yellow shorter hairs. Postnotum medium to dark brown, thinly whitish-gray pruinose, slightly shiny at certain angle of light, bare. Pleural membrane bare. Katepisternum longer than deep, medium brown, and bare. **Legs.** Foreleg: coxa dark yellow; trochanter dark yellow to ocherous; femur ocherous to light brown (though yellowish basally on inner surface) with apical cap dark brown; tibia dark brown with median portion of outer surface widely light brown and base narrowly ocherous; tarsus brownish-black; basitarsus cylindrical, 11.33 times as long as its greatest width. Midleg: coxa light brown with posterior surface dark brown; trochanter dark yellow except anterior surface clear yellow; femur dark yellow to ocherous with apical cap dark brown; tibia dark brown with median large portion on outer and inner surface light brown and base narrowly ocherous; tarsus medium brown to brownish-black. Hind leg: coxa light brown; trochanter yellow; femur dark yellow to ocherous (though yellowish on inner surface) with apical cap medium to dark brown; tibia dark brown with median portion on outer and inner surface medium brown and base narrowly ocherous; tarsus medium to dark brown except basal 1/3 (or a little more) of basitarsus and basal 1/2 of 2nd segment light brown (though base of basitarsus dark brown); basitarsus (Fig. 6B) spindle-shaped, 4.79 times as long as wide, and 0.97 times and 0.97 times as wide as hind tibia and femur, respectively; calcipala (Fig. 6B) well developed, 0.77 times as long as its basal width, and 0.40 times as wide as greatest width of basitarsus; pedisulcus (Fig. 6B) well developed. **Wing.** Length 3.1 mm.

Costa with dark short spines as well as dark hairs. Subcosta bare. Basal portion of radius fully haired; R_1 with dark spinules and hairs; R_2 with dark hairs. Hair tuft on stem vein dark brown. Basal cell absent. **Abdomen.** Basal scale dark brown, with fringe of yellow long hairs. Dorsal surface of abdominal segments medium to dark brown, tergites 2–8 faintly grayish pruinose, and slightly shiny dorsolaterally when viewed at certain angle of light, covered with dark simple hairs. **Genitalia.** Coxite in ventral view (Fig. 6C) subquadrate, 1.65 times as long as wide. Style in ventral view (Fig. 6C) short, 0.84 times as long as coxite, bent inwardly, with stout spine apically; style in lateral view (Fig. 6D) with apex sharply pointed dorsally; style in ventrolateral view (Fig. 6E) broad, nearly parallel-sided from base to beyond middle, then abruptly tapered apically; style in end view (Fig. 6F) nearly parallel-sided medially, with tapered apex having large spine. Ventral plate in ventral view (Fig. 6C) lamellate, 0.40 times as long as wide, well sclerotized, with 3 very shallow concavities on posterior margin, and moderately covered with fine short setae on ventral surface (except lateral portions partially setose); arm of moderate length, slender, and directed inwardly and dorsally; ventral plate in lateral view (Fig. 6G) nearly quadrate, and arm directed forwardly and dorsally; ventral plate in end view (Fig. 6H) with fine short setae centrally on posterior surface. Median sclerite in posteroventral view (Fig. 6I) simple, club-shaped, narrow, slightly widened toward apex. Paramere (Fig. 6J) with 5 (left side) or 6 hooks (right side) of short to long lengths gradually shortened toward apex. Aedeagal membrane in end view (Fig. 6K) moderately covered with microsetae; dorsal plate in end view (Fig. 6K) moderately sclerotized, inverted-T shaped. Ventral surface of 10th segment (Fig. 6L, M) without any hairs near each posterolateral corner. Cercus (Fig. 6L, M) small, rounded and encircled with 10 or 11 simple hairs.

Pupa. Body length 4.0 mm. **Head.** Integument yellowish-brown to medium brown, moderately covered with round tubercles; antennal sheaths bare; frons with 2 simple slender short trichomes (Fig. 7A) on each side; face with 1 simple stout trichome (apical portion lost, therefore exact length not measureable but apparently over 3 times as long as frontal trichomes) (Fig. 7B) on each side. **Thorax.** Integ-

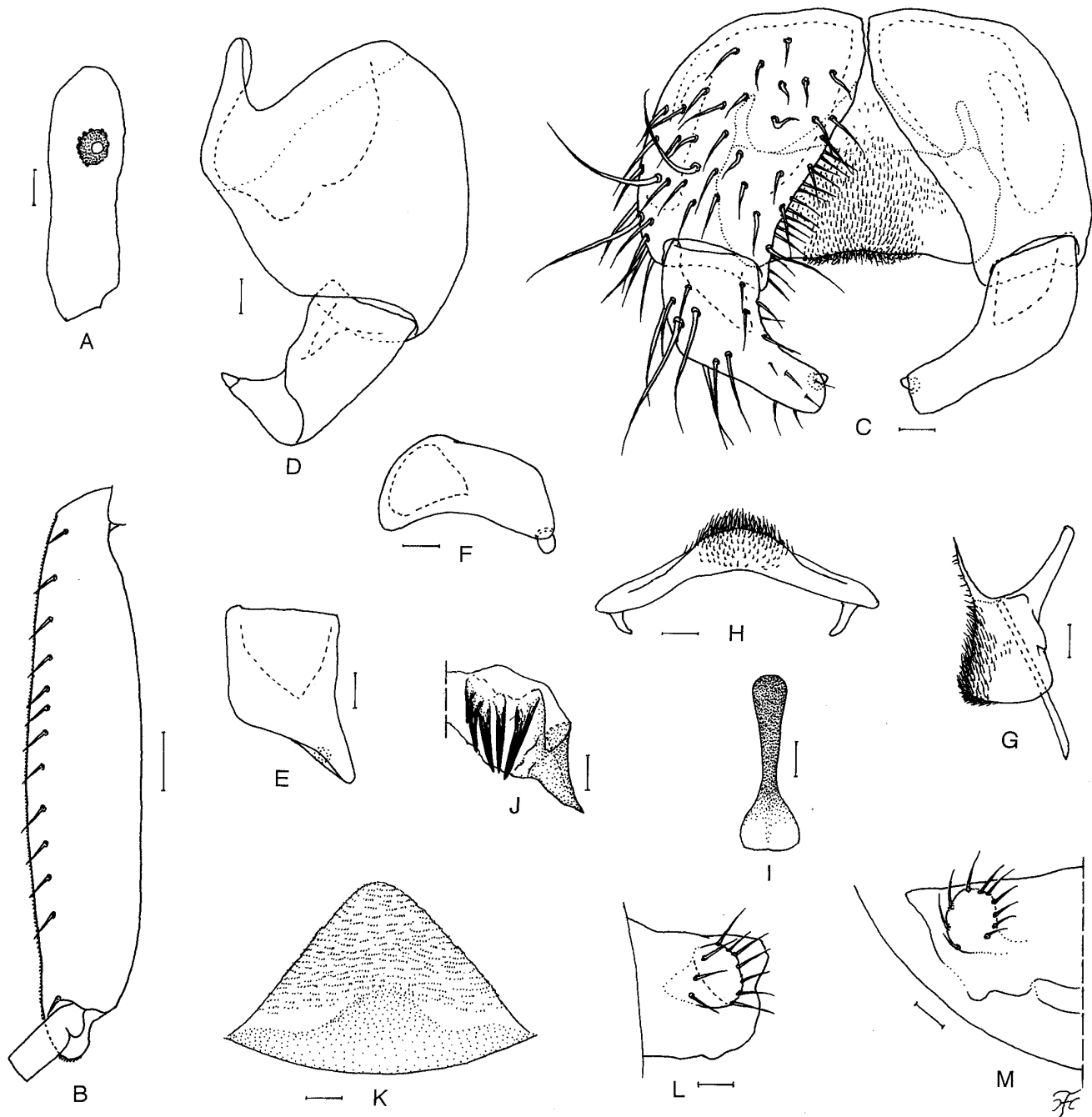


Fig. 6. Male of *Simulium* (*Nevermannia*) *mongarensis* sp. nov. A, 3rd segment of maxillary palp with sensory vesicle (right side; front view); B, hind basitarsus and 2nd tarsal segment (left side; outer view); C, coxites, styles and ventral plate *in situ* (ventral view); D, coxite and style (right side; lateral view); E and F, style (right side; E, ventrolateral view; F, end view); G, ventral plate and median sclerite *in situ* (lateral view); H, ventral plate (end view); I, median sclerite (ventroposterior view); J, paramere (left side; end view); K, aedeagal membrane and dorsal plate *in situ* (end view); L and M, 10th abdominal segment and cercus *in situ* (right side; L, lateral view; M, end view). Scale bars. 0.1 mm for B; 0.02 mm for A and C–M.

ument dark yellow to medium brown, moderately or sparsely covered with round tubercles, with 3 simple slender very long trichomes with coiled or uncoiled apex mediodorsally, 2 simple slender trichomes with uncoiled apices (1 very long, 1 medium-long) mediolaterally, 1 simple

slender medium-long trichome with uncoiled apex posterolaterally, and 3 simple slender trichomes with uncoiled apices (1 medium-long, 2 very short) ventrolaterally, on each side. Gill (Fig. 7C–E) with 6 long thread-like slender filaments arranged in 2 groups (1 ventral group

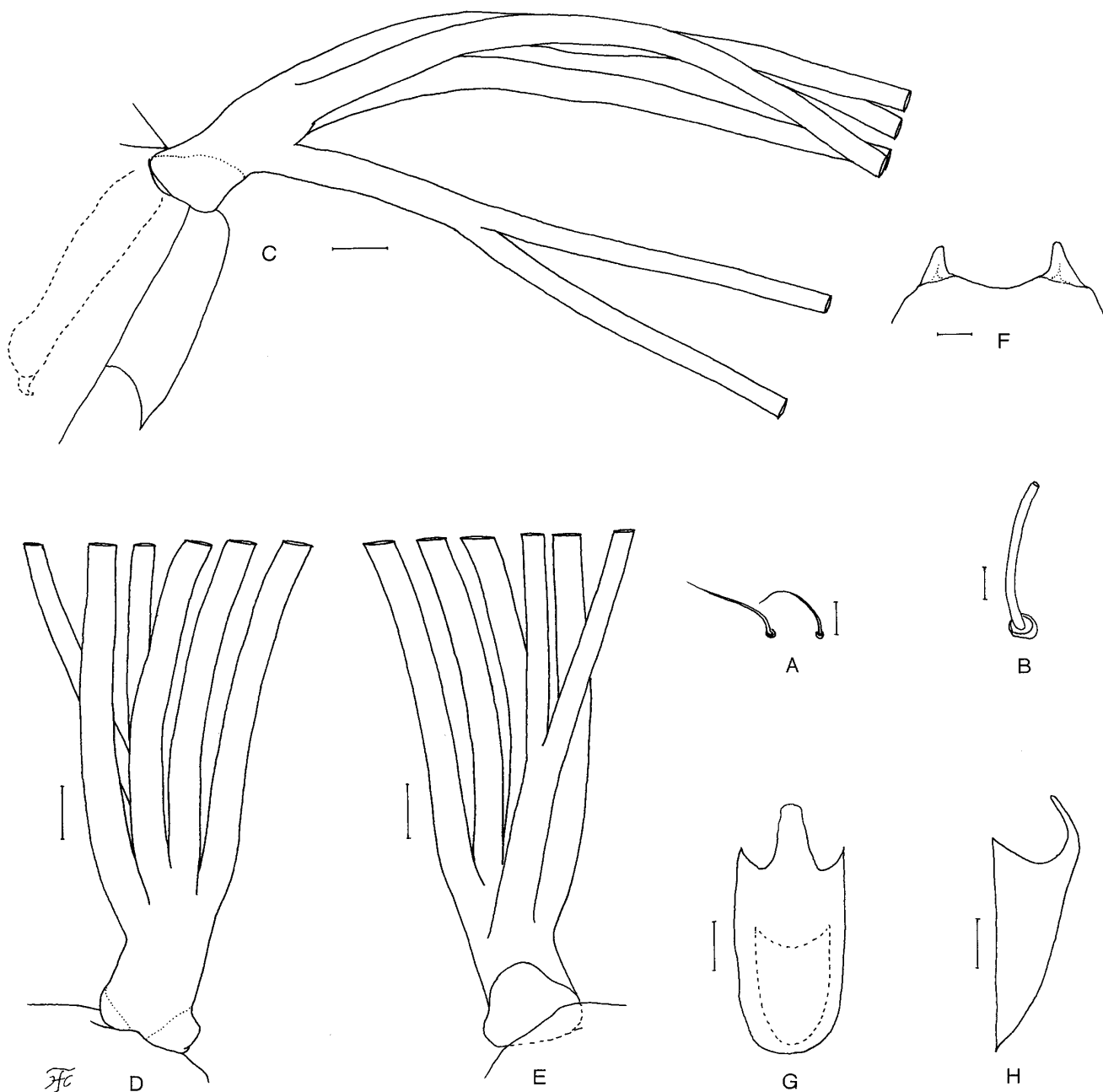


Fig. 7. Pupa of *Simulium* (*Nevermannia*) *mongarensis* sp. nov. A, frontal trichomes; B, facial trichome (broken); C-E, basal portion of gill filaments (right side; C, lateral view; D, dorsal view; E, ventral view); F, terminal hooks (end view); G and H, cocoon (G, dorsal view; H, lateral view). Scale bars. 1.0 mm for G and H; 0.1 mm for C-E; 0.02 mm for F; 0.01 mm for A and B.

consisting of paired filaments with stalk of moderate length, and dorsal group consisting of 4 filaments), arising from short common basal stalk; 4 filaments of dorsal group usually arising close together, lying nearly side by side horizontally; middle 2 filaments sharing very short stalk; inner individual filament slightly thicker than 3 other filaments of dorsal group which are subequal in thickness to one another (inner filament 1.11 times as thick as others when compared near base); 2 filaments of ven-

tral pair subequal in thickness to each other, and 0.74 as thick as inner individual filament of dorsal group; stalk of ventral pair nearly as thick as inner individual filament of dorsal group; common basal stalk with transparent bulb-like organ ventrally; all filaments light brown, directed forward and/or ventrally, then forward, tapered apically, probably slightly different in length from one another (apices of all filaments were lost, therefore no exact lengths were available; maximum and mini-

mm lengths of broken filaments are 4.3 mm and 3.2 mm), and longer than pupal body; cuticular surface with distinct annular ridges and furrows (though ridges becoming indistinct apically), and densely covered with minute tubercles. **Abdomen.** Dorsal surface of segments 1–4 strongly sclerotized, medium brown, moderately and elaborately covered with minute tubercles; dorsal surface of segments 5–9 weakly sclerotized, light brown, and without minute tubercles; segment 1 with 1 simple slender short seta on each side; segment 2 with 1 simple slender short seta, 5 spinous short setae submedially and 2 spinous short setae laterally on each side; segments 3 and 4 each with 4 hooks and 1 spinous short seta submedially and 2 spinous short setae laterally on each side; segments 5–8 each with spine-combs directed backward in transverse row and 1 spinous short seta submedially on each side; segments 6–9 each with comb-like groups of minute spines on each side; segment 9 with pair of distinct cone-shaped terminal hooks (Fig. 7F). Ventrally, segments 3–8 with comb-like groups of minute spines; segment 4 with 2 simple hooklets on each side; segment 5 with pair of bifid hooks submedially and few slender short setae on each side; segments 6 and 7 each with 1 bifid hook submedially and 1 simple hook laterally, and few slender setae on each side. **Cocoon** (Fig. 7G, H). Simple, wall-pocket-shaped, compactly woven without open spaces in web, with elongate anterodorsal projection gently curved ventrally; individual threads invisible; 4.2 mm long by 2.2 mm wide.

Mature larva. Body length 7.0–7.5 mm. Body grayish except posterior abdominal segments yellowish or grayish-yellow, with well-defined colored markings (Fig. 8A) somewhat variable by individual larvae; i.e., thoracic segment 1 very rarely with dark brown narrow transverse band, abdominal segment 1 with small reddish-brown lateral spot on each side; abdominal segment 2 with similar reddish-brown lateral spot and rarely with small reddish-brown dorsal spot submedially on each side; abdominal segments 3 and 4 each with 3 reddish-brown spots on each side, of which 1 spot lying medially on lateral surface and 2 spots lying submedially on dorsal surface (those spots often very narrowly connected to each other); abdominal segment 5 on each side with 1 reddish-brown small spot submedially on anterior 1/2 of dorsal surface and 1 similar

colored transverse band along its posterior margin; abdominal segment 6 on each side with 2 reddish-brown small submedial spots on dorsal surface, of which 1 spot lying on anterior 1/2 and 1 spot in front of posterior margin; abdominal segment 7 with reddish-brown broad transverse band along anterior margin though often broken medially; abdominal segment 8 with reddish-brown dorsolateral area on each side, which is usually connected to that on segment 7. Cephalic apotome yellow except posterior margin somewhat darkened, with distinct positive head spots; lateral surface of head capsule yellow, with distinct eyebrow containing dark spot; 2 large spots behind eye-spot region and 3 isolated spots below eye-spot region distinctively positive; ventral surface of head capsule (Fig. 8B) yellow (though postgenal bridge mostly darkened except anterior narrow area), with dark basal area on each side of postgenal cleft; horizontal and round spots on each side of postgenal cleft distinctively positive. Cervical sclerite composed of 2 small elliptical pieces, not fused to occiput, very widely separated medially from each other. Antenna consisting of 3 segments and apical sensillum, much longer than stem of labral fan; proportional lengths of 1st, 2nd, and 3rd segments 1.00:0.93:0.65. Labral fan with 24 main rays. Mandible (Fig. 8C) with mandibular serrations consisting of 2 teeth (1 large and 1 small); large tooth making nearly right angle with mandible on apical side; supernumerary serrations absent; comb-teeth composed of 3 teeth, shortened from 1st to 3rd. Hypostoma (Fig. 8D) with 9 apical teeth in row; median and corner teeth well developed; median tooth of 3 intermediate teeth on each side smallest; lateral serrations weakly developed apically; 5–7 hypostomal bristles lying nearly parallel to lateral margin on each side. Postgenal cleft (Fig. 8B) small, 0.43–0.53 times as long as postgenal bridge, with anterior margin roughly rounded or irregularly defined. Thoracic cuticle bare. Abdominal cuticle bare except both sides of anal sclerite moderately covered with simple colorless setae, and lateral surface of last segment down to middle of ventral papilla also moderately covered with similar but shorter setae. Rectal scales present. Rectal papilla compound, each of 3 lobes with 17–19 finger-like secondary lobules. Anal sclerite of usual X-form, with anterior arms slightly shorter than posterior ones, broadly sclerotized basally

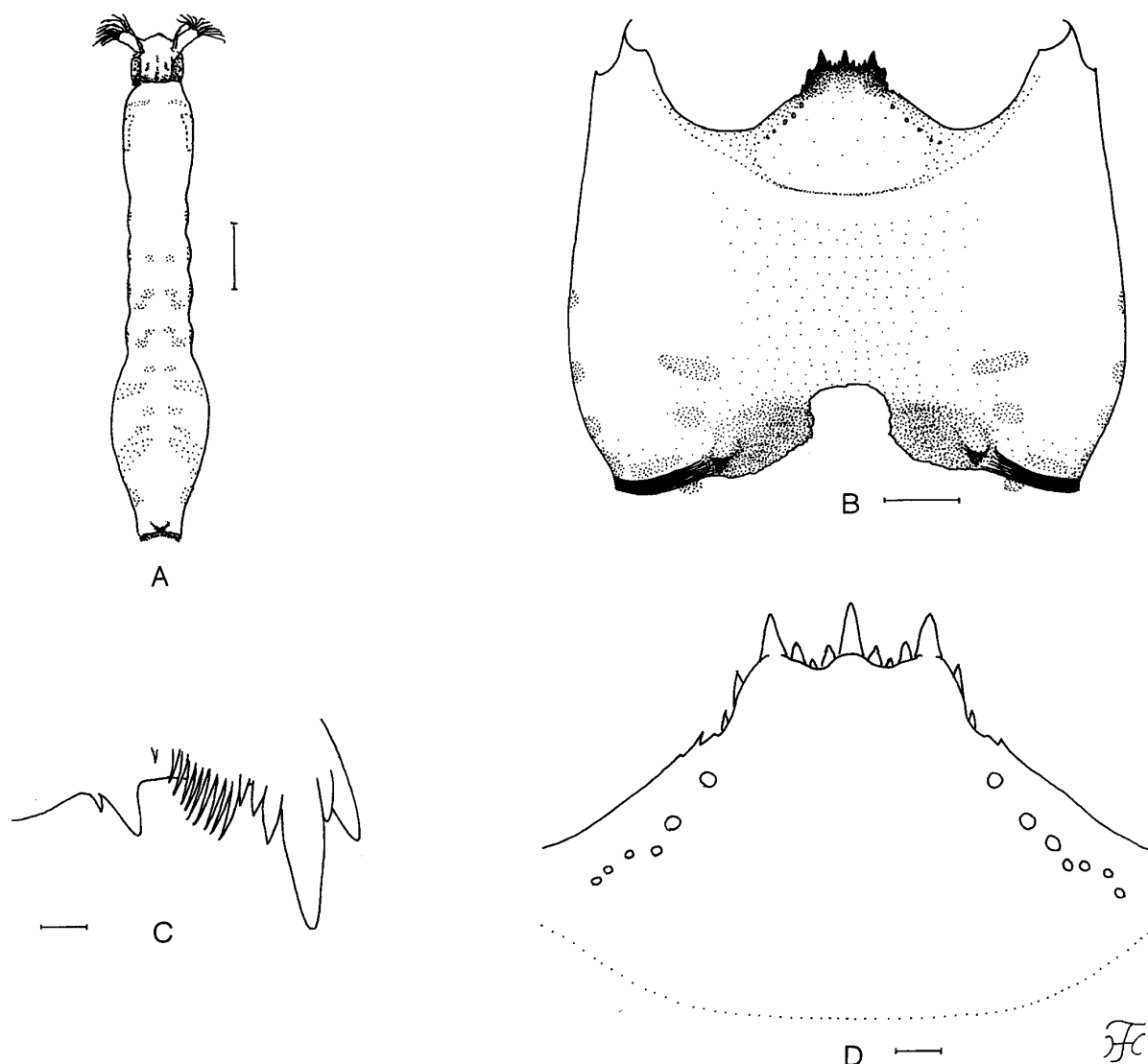


Fig. 8. Mature larva of *Simulium* (*Nevermannia*) *mongarensis* sp. nov. A, whole body (dorsal view); B, head capsule showing postgenal cleft (ventral view); C, mandible; D, hypostoma. Scale bars. 1.0 mm for A; 0.1 mm for B; 0.02 mm for D; 0.01 mm for C.

between anterior arms; sensilla absent on and just posterior to basal juncture area; accessory sclerite absent. Last abdominal segment much expanded ventally forming large ventral papilla. Posterior circlet with 72–78 rows of up to 13 hooklets per row.

TYPE SPECIMENS. Holotype male (with associated pupal exuviae and cocoon), reared from pupa collected from a small stream (width 20 cm, depth 5 cm, water temperature 17.4°C, exposed to sun, altitude 2,344 m; 27° 16' 54" N, 91° 18' 45" E), moderately flowing in a densely forested area, Korila, Mongar, Bhutan, 2. IX. 2007. Paratypes: 7 mature larvae, same

data and date as those of the holotype.

BIOLOGICAL NOTES. The pupae and larvae of this new species were collected from stalks of trailing grasses. The associated species were *S. (M.) dattai* sp. nov. and *S. (M.) nemorivagum*. The mosquito larvae of *Anopheles bengalensis*, *An. baileyi* and *An. lindesayi* were also collected.

ETYMOLOGY. The species *mongarensis* refers to the locality, Mongar, where this new species was found.

REMARKS. *Simulium* (*Nevermannia*)

mongarense sp. nov. is readily assigned to the *feuerborni* species-group of the subgenus *Nevermannia* in having the combination of the following characteristics: male genitalia with a simple lamellate ventral plate (Fig. 6C), a short inwardly-twisted style (Fig. 6E), a simple narrow median sclerite (Fig. 6I) and several parameral hooks (Fig. 6J), pupal gill with six long thread-like filaments per side (Fig. 7C), and larval head with small short postgenal cleft (Fig. 8B).

The characteristic arrangement of the pupal gill (Fig. 7C–E) together with the cocoon with an elongate anterodorsal projection (Fig. 7G, H) appears to relate *S. (N.) mongarense* sp. nov. to three known species, i.e., *S. (N.) feuerborni* Edwards originally described from Java (Edwards, 1934), *S. (N.) leigongshanense* Chen and Zhang from China (Chen and Zhang, 1997) and *S. (N.) praelargum* Datta from India (Datta, 1973). However, this new species is distinguished from all these known species in the male by the number of horizontal rows of large eye-facets which is 20 in this new species, 17 or 18 in *S. (N.) feuerborni*, 16 in *S. (N.) leigongshanense* and 17 in *S. (N.) praelargum*. This new species is also distinguished from *S. (N.) feuerborni* by the number of parameral hooks (5 or 6 in this new species and 3 or 4 in *S. (N.) feuerborni*), from *S. (N.) leigongshanense* by the length of the stalk of the ventral paired filaments (medium-long in this new species and very long in *S. (N.) leigongshanense*), and from *S. (N.) praelargum* by the number of secondary lobules of the larval rectal papilla (17–19 in this new species and 5–8 in *S. (N.) praelargum*). *Simulium (N.) fangense* Takaoka and Choochote from Thailand (Takaoka and Choochote, 2006) shows close similarities to this new species in many features including the number of the horizontal rows of the large facets, the number of the parameral hooks, the presence of the anterodorsal projection of the cocoon, and the number of secondary lobules of the rectal papilla, but differs in that the

number of the vertical columns of the large eye-facets is 21, the ventral margin of the ventral plate is concave when viewed laterally, the gill filaments are arranged as 2+1+1+2 or 2+2+1+1 or 3+1+2 filaments, and the anterodorsal projection of the cocoon is short.

The four known species of the *feuerborni* species-group were described from adult males (and also females in one species) alone, their pupal and larval stages remaining unknown. Among these, *S. (N.) fuscineris* Edwards recorded from Sabah (Edwards, 1933) differs from the new species by having the paramere with 10 or 11 hooks; *S. (N.) bryopodium* Delfinado, described from Palawan Island, Philippines (Delfinado, 1971), also differs by the dark brown hind femora and the ventral plate much depressed posteriorly; *S. (N.) senile* Brunetti, described from West Himalaya (Brunetti, 1911), is different by the style without apical spine; *S. (N.) rufithorax* Brunetti, described from a male and four females collected from India (Brunetti, 1911), has a reddish-brown thorax according to the original description.

Simulium (Nevermannia) thrimshinglaense Takaoka and Somboon sp. nov.

DESCRIPTION. Female. Body length 2.2–2.4 mm. **Head.** Slightly narrower than width of thorax. Frons dark brown, thinly whitish-gray pruinose, slightly shiny at certain angle of light, moderately covered with yellow recumbent short hairs interspersed with few dark brown long hairs along lateral margins; frontal ratio 1.55–1.69:1.00:1.90–2.21. Frons-head ratio 1.00:4.64–4.82. Fronto-ocular area (Fig. 9A) directed laterally and slightly upwardly, rounded apically. Clypeus dark brown, thinly whitish-gray pruinose, slightly shiny at certain angle of light, moderately covered with yellow short hairs interspersed with several dark brown long hairs on lower 2/3 though upper and lower medial portions widely bare. Labrum 0.82–0.87 times as long as clypeus. Antenna composed of scape, pedicel and 9 flagellomeres, entirely dark brown; 1st flagel-

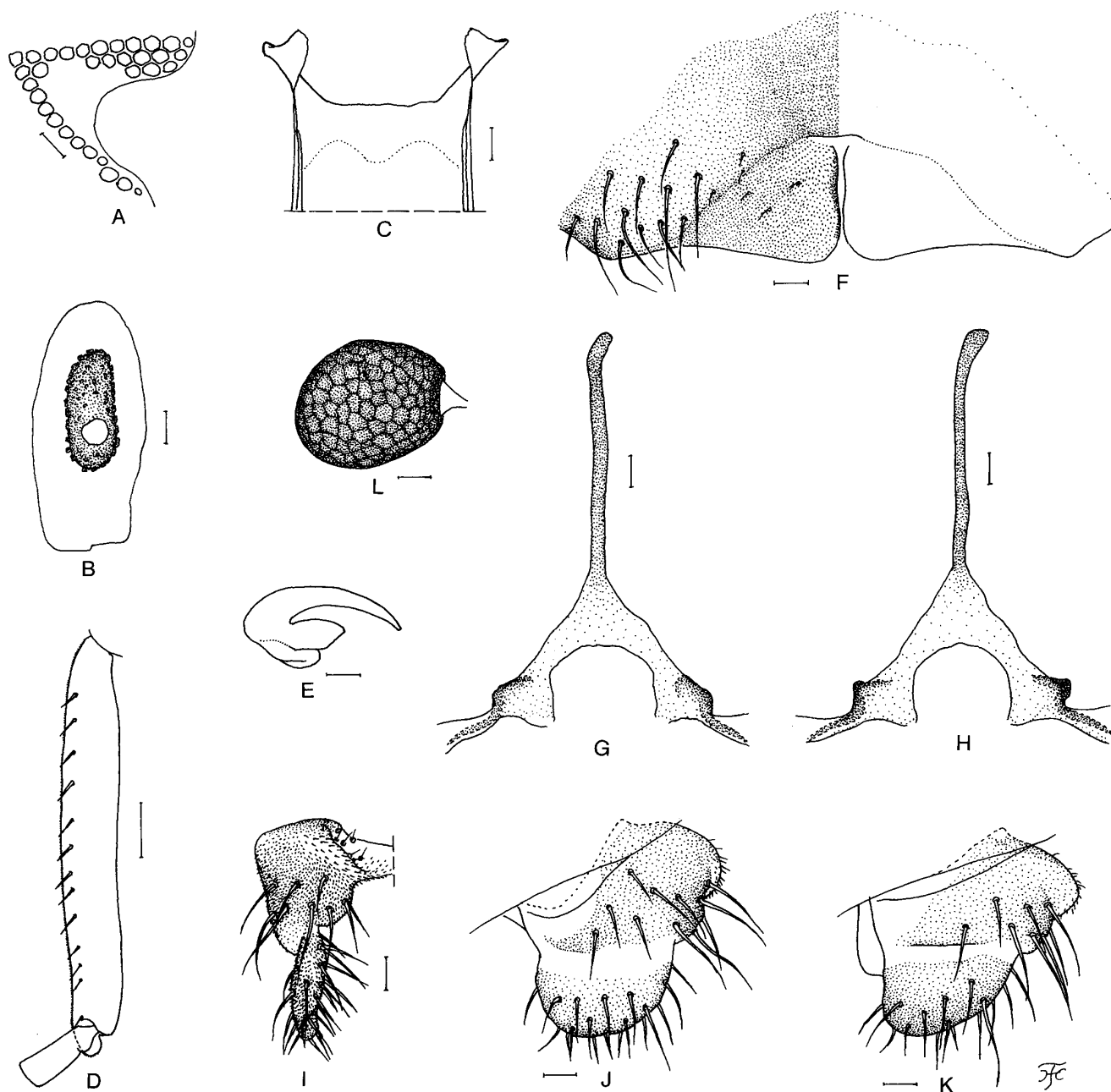


Fig. 9. Female of *Simulium* (*Nevermannia*) *thrimshinglaense* sp. nov. A, fronto-ocular area (right side; front view); B, 3rd segment of maxillary palp with sensory vesicle (right side; front view); C, upper portion of cibarium; D, hind basitarsus and 2nd tarsal segment (left side; outer view); E, tarsal claw; F, 8th sternite and ovipositor valves *in situ*; G and H, genital fork (G, arm with round ridge; H, arm with angulated ridge); I-K, paraproct and cercus (right side; I, ventral view; J and K, lateral view; J, cercus rounded posteriorly; K, cercus triangular); L, spermatheca. Scale bars. 0.1 mm for D; 0.03 mm for A; 0.02 mm for B, C and F-L; 0.01 mm for E.

lomere 1.56 times as long as 2nd one. Maxillary palp composed of 5 segments, light to medium brown, proportional lengths of 3rd, 4th, and 5th segments 1.00 : 0.81 : 1.60; 3rd segment (Fig. 9B) enlarged; sensory vesicle (Fig. 9B) enlarged, ellipsoidal, 0.43–0.48 times as long as 3rd segment, and with medium-sized opening submedially. Maxillary lacinia with

11–13 inner and 11–14 outer teeth. Mandible with 33 inner and 12 outer teeth. Cibarium (Fig. 9C) smooth. **Thorax.** Scutum brownish-black except anterolateral calli medium brown, slightly shiny at certain angle of light, densely covered with yellow recumbent short hairs interspersed with dark long upright hairs on pre-scutellar area. Scutellum medium to dark

brown, slightly shiny at certain angle of light, covered with yellow short hairs and dark long hairs. Postnotum dark brown, slightly shiny at certain angle of light, bare. Pleural membrane bare. Katepisternum dark brown, longer than deep, shiny, and bare. **Legs.** Foreleg: coxa dark brown; trochanter medium brown; femur light brown except apical cap dark brown; tibia dark brown except medial portion of outer surface widely light brown; tibia densely covered with yellow hairs on outer surface of basal 3/4; tarsus brownish-black; basitarsus cylindrical, 9.18 times as long as its greatest width. Midleg: color similar to that of foreleg; tibia densely covered with yellow hairs on posterior surface. Hind leg: coxa light to medium brown; trochanter and femur light brown except apical cap of femur dark brown; tibia light brown except subbasal portion and apical cap dark brown; tibia densely covered with yellow hairs on basal 3/5; basitarsus light brown; rest of tarsus medium brown except basal 1/2 of 2nd segment light brown; basitarsus (Fig. 9D) slender, nearly parallel-sided, 7.19 times as long as wide, and 0.84 and 0.73 times as wide as tibia and femur, respectively; calcipala well developed, 0.77 times as long as basal width, and 0.48 times as wide as greatest width of basitarsus; pedisulcus well developed at basal 1/4 of 2nd tarsal segment; claws (Fig. 9E) each with large basal tooth 0.50 times as long as claw. **Wing.** Length 2.9–3.0 mm. Costa with dark spinules and hairs. Subcosta with dark hairs except apical 1/5 to 1/4 bare. Hair tuft on stem vein dark brown. Basal portion of radial vein fully haired. R_1 with dark spinules and hairs. R_2 with dark hairs only. Basal cell and basal median cell absent. **Abdomen.** Basal scale medium brown, with fringe of yellow long hairs; dorsal surface of segment 2 ochreous except tergal plate and narrow area along posterior margin dark brown; those of other segments medium brown; tergites 6–9 shiny when illuminated at certain angle of light; ventral surface of segments 2–4 ochreous, other segments light to medium brown; segment 7 with large sternal plate medially. **Genitalia.** Sternite 8 (Fig. 9F) bare medially, and with 11–13 medium-long to long hairs and few short fine setae on each side. Ovipositor valves (Fig. 9F) roughly triangular, rounded medioposteriorly, thin, membranous, densely covered with microsetae interspersed with 3–6 fine short setae; inner margin moderately

sclerotized and narrowly darkened. Genital fork (Fig. 9G, H) of usual inverted-Y form, stem slender and well sclerotized; arms widened, each with round or angulated strongly-sclerotized apical ridge directed anterodorsally or laterodorsally. Paraproct in ventral view (Fig. 9I) quadrate, with strongly-sclerotized anterior surface, covered with 8–12 medium-long and long hairs on ventral and lateral surface, with 7–9 sensilla on anteromedial transparent surface; paraproct in lateral view (Fig. 9J, K) moderately produced ventrally beyond ventral margin of cercus, with ventral margin notched medially. Cercus in ventral view (Fig. 9I) narrow, nearly straight; cercus in lateral view (Fig. 9J, K) rounded or triangular, 0.54–0.58 times as long as wide, and with several dark medium-long to long hairs. Spermatheca (Fig. 9L) small, ovoidal, 1.12 times as long as its greatest width, well sclerotized except small area at juncture with duct, with reticulate surface pattern; internal setae absent; both accessory ducts subequal in diameter to each other, and slightly larger in diameter than main duct.

Male. Body length 2.8 mm. **Head.** Slightly wider than width of thorax. Upper eye consisting of 20 vertical columns and 23 horizontal rows of large facets. Face dark brown, white pruinose. Clypeus dark brown, white pruinose, moderately covered with dark brown long hairs except mediolongitudinal portion bare. Antenna composed of scape, pedicel and 9 flagellomeres, entirely dark brown; 1st flagellomere somewhat elongate, 2.06 times as long as 2nd one. Maxillary palp composed of 5 segments, light to medium brown, proportional lengths of 3rd, 4th, and 5th segments 1.00 : 0.98 : 1.98; sensory vesicle (Fig. 10A) small, ellipsoidal, 0.25–0.27 times as long as 3rd segment, with small opening apically. **Thorax.** Scutum black, gray pruinose and shiny on each shoulder, narrow area along each lateral margin and prescutellar area at certain angle of light, densely covered with golden-yellow short hairs interspersed with dark upright hairs on prescutellar area. Scutellum dark brown, with yellow short hairs and dark long upright hairs. Postnotum dark brown, bare. Pleural membrane and katepisternum as in female. **Legs.** Color pattern as in female though much darker in male; fore basitarsus cylindrical, 9.88 times as long as its greatest width; hind basitarsus (Fig. 10B) enlarged, spindle-shaped, 3.72 times as long as its great-

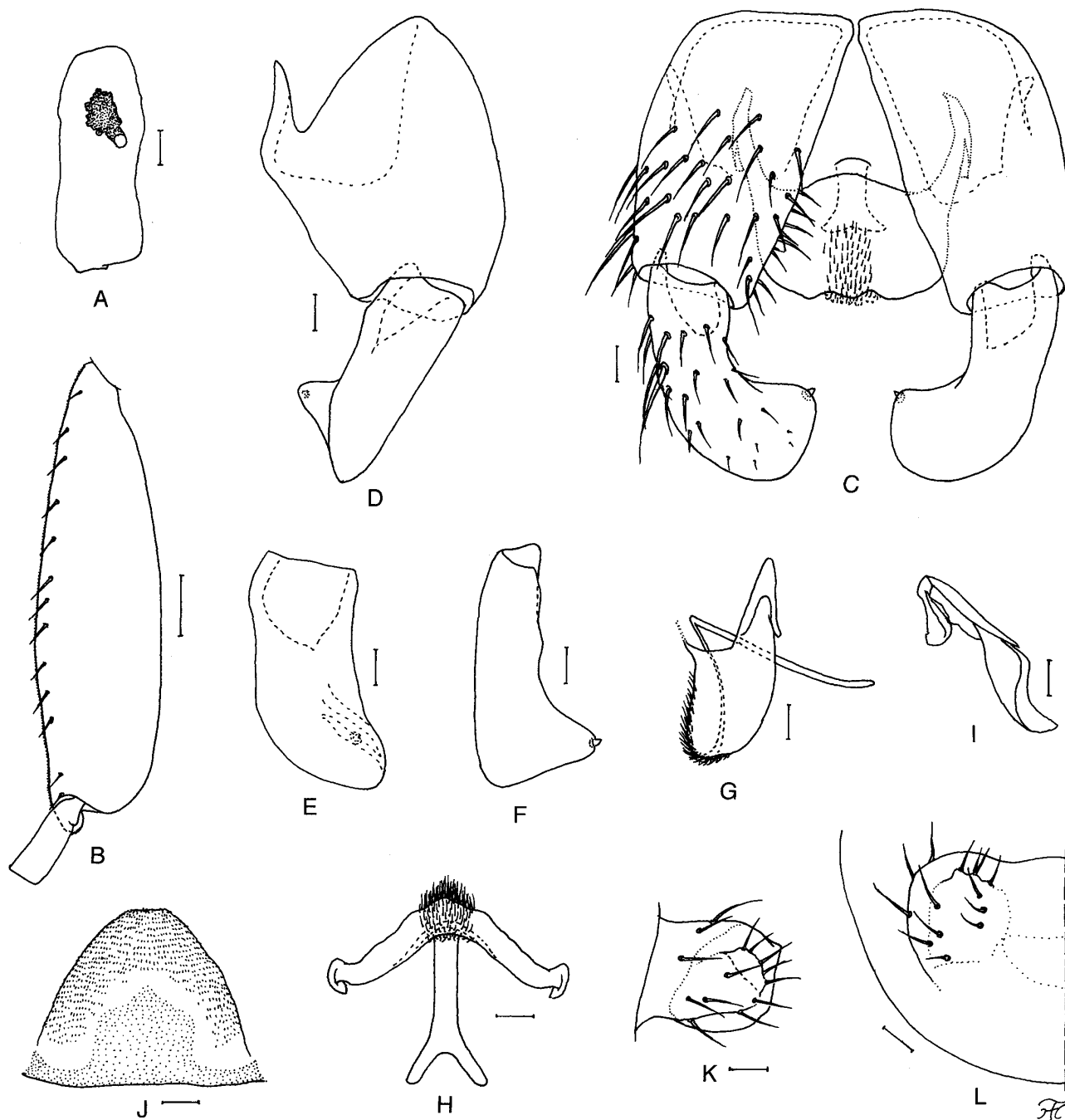


Fig. 10. Male of *Simulium* (*Nevermannia*) *thrimshinglaense* sp. nov. A, 3rd segment of maxillary palp with sensory vesicle (right side; front view); B, hind basitarsus and 2nd tarsal segment (left side; outer view); C, coxites, styles and ventral plate *in situ* (ventral view); D, coxite and style (right side; lateral view); E and F, style (right side; E, ventrolateral view; F, medial view); G and H, ventral plate and median sclerite *in situ* (G, lateral view; H, end view); I, paramere (left side; end view); J, aedeagal membrane and dorsal plate *in situ* (end view); K and L, 10th abdominal segment and cercus *in situ* (right side; K, lateral view; L, end view). Scale bars. 0.1 mm for B; 0.02 mm for A and C-L.

est width, and 1.36 times as wide as greatest width of hind tibia which is as wide as hind femur; calcipala well developed, 0.78 times as long as its basal width, and 0.26 times as wide as greatest width of basitarsus; pedisulcus well developed at basal 1/4 of 2nd tarsal segment. **Wing.** As in female except length 2.8 mm, and

subcosta bare. **Abdomen.** Basal scale dark brown, with fringe of dark long hairs. Dorsal surface of abdominal segments dark brown to brownish-black, moderately covered with dark short and long hairs; when viewed at certain angle of light, all tergites slightly shiny dorsally or dorsolaterally; ventral surface of

abdomen ochreous to light brown except all sternites medium brown, and shiny when viewed at certain angle of light. **Genitalia.** Coxite in ventral view (Fig. 10C) rectangular, 1.95 times as long as wide. Style in ventral view (Fig. 10C) curved inwardly, nearly parallel-sided, and with apical spine; style in lateral view (Fig. 10D) narrow, with triangular flange directed dorsally; style in ventrolateral view (Fig. 10E) nearly parallel-sided from base to apical 1/4, then tapered toward round apex, 2.11 times as long as its basal width, and 0.70 times as long as coxite; style in medial view (Fig. 10F) boot-shaped, with inwardly-directed triangular flange with small spine at its apex. Ventral plate in ventral view (Fig. 10C) transverse, plate-like, very slightly tapered posteriorly, 0.66 times as long as wide, with 2 shallow depressions on posterior margin, and with minute setae medially on posterior 1/2 of ventral surface; arms well sclerotized, slender, slightly directed outwardly, then inwardly; ventral plate in lateral view (Fig. 10G) not produced ventrally, and with arm directed forward, tapered toward apex; ventral plate in end view (Fig. 10H) gently rounded ventrally, with ventral margin undulate, and setose medially on posterior surface. Median sclerite in lateral view (Fig. 10G) arising just before anterior margin of ventral plate, and in end view (Fig. 10H) narrow, nearly parallel-sided, and forked apically. Paramere in end view (Fig. 10I) narrow, with 1 long parameral hook directed laterally, and with small isolated sclerotized plate near base of hook. Aedeagal membrane (Fig. 10J) moderately covered with microsetae except near dorsal plate almost bare, and dorsal plate in end view (Fig. 10J) moderately sclerotized, widely extended ventrally in middle. Abdominal segment 10 (Fig. 10K, L) with 1 hair near posterolateral corner on ventral surface and 2 hairs on lateral surface on each side. Cercus (Fig. 10K, L) slightly darkened, rounded, and with 10 or 11 hairs.

Pupa. Body length (excluding gill filaments) 3.0–3.2 mm. **Head.** Integument (Fig. 11A) light yellowish-brown, almost smooth though few tubercles present; antennal sheath bare; frons with 3 simple long trichomes (Fig. 11A) on each side; face with 1 simple long trichome (Fig. 11A) on each side. **Thorax.** Integument light yellowish-brown, smooth except little more than posterior 1/2 sparsely covered with small tubercles, and on each side with 3 simple

very long trichomes mediodorsally (Fig. 11B), 2 simple trichomes (1 very long, 1 medium-long) anterolaterally (Fig. 11C), 1 simple medium-long trichome posterolaterally (Fig. 11D), and 3 simple short trichomes ventrolaterally (Fig. 11E). Gill (Fig. 11F–H) with 4 slender thread-like filaments, shorter than pupal body, arranged vertically in dorsal and ventral pairs arising from common basal stalk of moderate length; common basal stalk nearly as thick as or little thicker than interspiracular trunk, and with transparent swollen portion ventrally; stalk of ventral pair shorter than both common basal stalk and stalk of dorsal pair on right side (Fig. 11F) and much longer than stalk of dorsal pair which is longer than common basal stalk on left side (Fig. 11G) in 1 pupa; stalk of ventral pair shorter than common basal stalk but longer than stalk of dorsal pair on each side in another pupa (Fig. 11H); stalk of dorsal pair slightly thicker than stalk of ventral pair; dorsal filament of dorsal pair longest (2.5 mm long) and thickest of all, other 3 filaments which are subequal in length (1.7–1.9 mm long) and thickness one another (0.82 times as thick as dorsal filament of dorsal pair); all filaments medium brown, directed forward, gradually tapered toward apex, furnished with annular ridges and furrows, and densely covered with minute tubercles on outer surface. **Abdomen.** Dorsally, segments 1 and 2 very weakly sclerotized, light yellow and very weakly tuberculate; segment 1 with 1 simple slender medium-long seta on each side (Fig. 11I); segment 2 with 1 simple slender seta and 5 dark spinous short setae on each side (Fig. 11J); segments 3 and 4 each with 4 dark stout hooks and 1 dark short spinous seta on each side; segments 5–8 each with spine-combs lying transversely along anterior margin on each side; segments 6–9 each with comb-like groups of minute spines in transverse rows on each side; segment 9 with pair of cone-shaped terminal hooks (Fig. 11K, L). Ventrally, segment 4 with 1 dark simple hooklet (slightly shorter and smaller than those on segments 5–7) and 3 simple short setae on each side; segment 5 with 2 dark bifid hooks and few simple short setae on each side; segments 6 and 7 each with 1 dark bifid inner hook and 1 dark simple outer hook, and few simple short setae on each side; segments 4–8 with comb-like groups of minute spines. **Cocoon** (Fig. 11M, N). Wall-pocket-shaped, roughly woven, thin except anterior

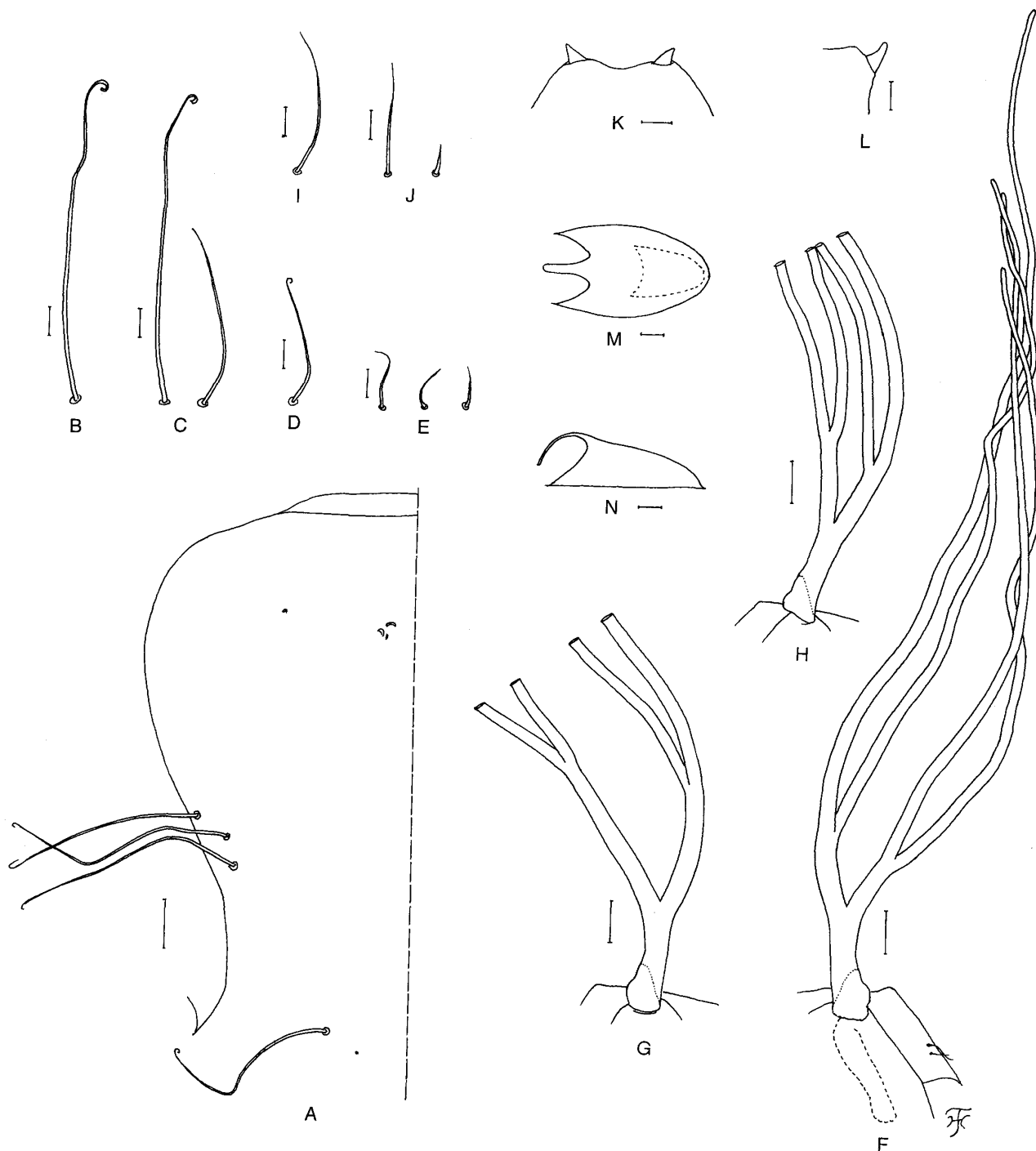


Fig. 11. Pupa of *Simulium* (*Nevermannia*) *thrimshinglaense* sp. nov. A, frons and part of face showing 3 frontal and 1 facial trichomes (right half); B-E, thoracic trichomes (B, mediodorsal; C, anterolateral; D, posterolateral; E, ventrolateral); F, gill filaments (right side; lateral view); G and H, basal portion of gill filaments showing stalks of dorsal and ventral pairs of different lengths; I, medium-long seta on dorsal surface of abdominal segment 1; J, medium-long seta and very short seta on dorsal surface of abdominal segment 2; K and L, terminal hooks (K, end view; L, lateral view); M and N, cocoon (M, dorsal view; N, lateral view). Scale bars. 0.5 mm for M and N; 0.1 mm for F-H; 0.05 mm for A; 0.03 mm for B-E, I and J; 0.02 mm for K and L.

margin thickly woven, and extending ventrolaterally, with very long narrow anterodorsal projection bent downward; floor woven on posterior 1/2; individual threads visible; 3.4-3.5

mm long by 1.8-2.2 mm wide.

Mature larva. Body length 5.0-5.8 mm. Body color whitish or yellowish-white though abdominal segments 1-4 (or to segment 5)

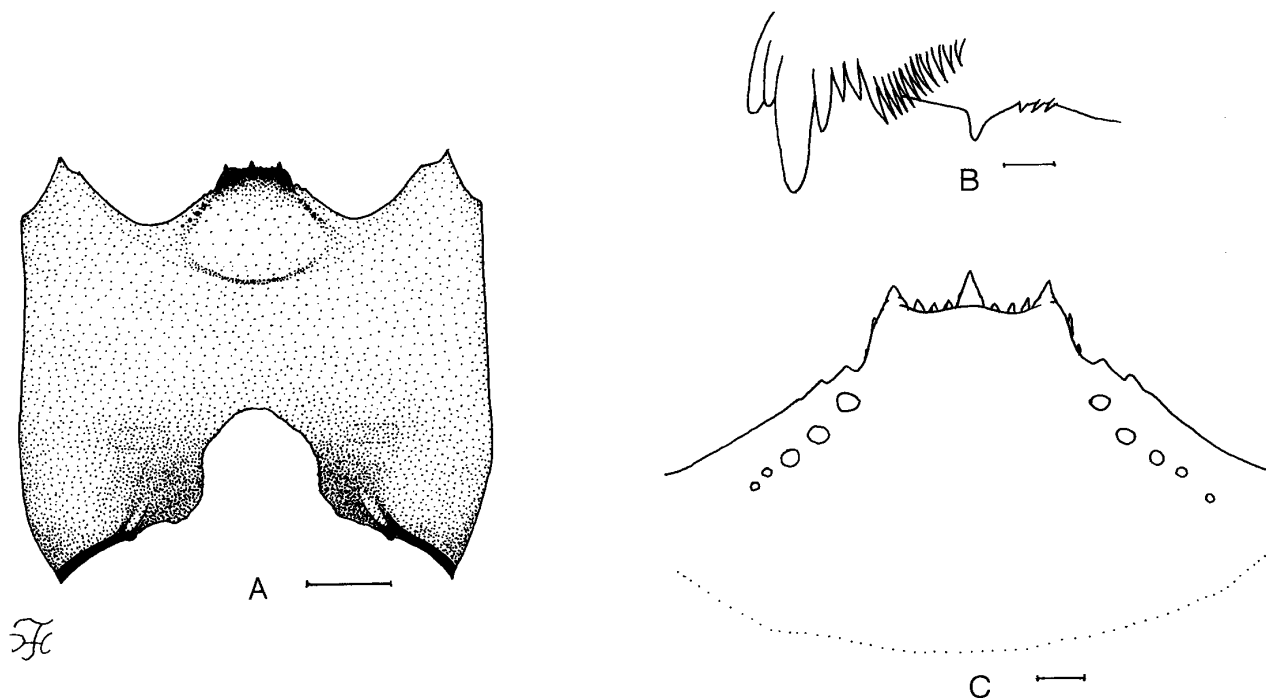


Fig. 12. Mature larva of *Simulium* (*Nevermannia*) *thrimshinglaense* sp. nov. A, head capsule showing postgenal cleft (ventral view); B, mandible; C, hypostoma. Scale bars. 0.1 mm for A; 0.02 mm for C; 0.01 mm for B.

grayish in some larvae. Cephalic apotome light to medium brown with posterior margin dark brown; head spots positive though some of spots merged into dark background color in some larvae. Lateral surface of head capsule light to medium brown except eye-spot region whitish and area in front of posterior margin darkened to varying degrees in some larvae; eyebrow well-defined, with 1 dark spot; 2 large and 1 or 2 small dark spots near posterior margin, and 1 small dark spot below eye-spot region distinctive, although 2 large spots merged into dark background color in some larvae. Ventral surface of head capsule (Fig. 12A) light to medium brown, with dark brown area on each side of postgenal cleft; elongate spot on each side of postgenal cleft positive but often merged into dark background color. Cervical sclerites composed of 2 brown rod-like small pieces, not fused to occiput (though fused to occiput in 1 mature larva), widely separated from each other. Antenna composed of 3 segments and apical sensillum, much longer than stem of labral fan; proportional lengths of 1st, 2nd, and 3rd segments 1.00 : 1.10 : 0.71. Labral fan with 32–34 rays. Mandible (Fig. 12B) with 1st comb-tooth longest, followed by 3rd one which is slightly longer than 2nd one; mandibular serrations composed of 2 teeth (1

large and 1 small); large tooth at obtuse angle to mandible on apical side; supernumerary serrations present. Hypostoma (Fig. 12C) with row of 9 apical teeth, median tooth most prominent, followed by corner teeth, and intermediate teeth smallest; lateral margins smooth except near apex serrated; hypostomal bristles 5 or 6 in row, lying nearly parallel to lateral margin on each side. Postgenal cleft (Fig. 12A) small, 0.74–0.80 times as long as postgenal bridge, rounded anteriorly. Thoracic and abdominal cuticle almost bare except last abdominal segment moderately covered with colorless minute setae on both sides of anal sclerite and on each lateral surface down to base of rectal papilla. Rectal scales darkened, well discernible. Rectal papilla compound, each lobe with 18–21 finger-like secondary lobules. Anal sclerite X-shaped, with basal juncture area broadly sclerotized; anterior arms much shorter than posterior ones; accessory sclerites absent; sensillum absent. Ventral papillae well developed, conical. Posterior circlet of hooks with 83–86 rows of up to 13 or 14 hooks per row.

TYPE SPECIMENS. Holotype female (with its associated pupal exuviae and cocoon), reared from a pupa collected from

a slow-flowing stream (width about 1 m, depth 10 cm, water temperature below 5°C, exposed to sun, altitude 3,720 m; 27°23'54"N, 90°59'39"E) in a densely forested area, near Thrimshingla, Mongar, Bhutan, 4. IX. 2007. Paratypes: 2 females, 3 mature larvae, same data and date as those of the holotype; 1 female and 1 male, 10 mature larvae, collected from a moderately flowing stream (width 30 cm, depth 10 cm, water temperature below 5°C, exposed to sun, altitude 3,596 m; 27°23'26"N, 90°58'46"E) in a densely forested area, below Thrimshingla, Mongar, Bhutan, 4. IX. 2007.

ECOLOGICAL NOTES. The pupae and larvae of this new species were collected from grass stalks, together with those of *S. (M.) nemorivagum* and *S. (S.) pradyai* sp. nov.

ETYMOLOGY. The specific name *thrimshinglaense* refers to the name of the locality, Thrimshingla, where this new species was collected.

REMARKS. *Simulium (N.) thrimshinglaense* sp. nov. is assigned to the *vernum* species-group within the subgenus *Nevermannia* in that it has the male ventral plate lamellate, without a median keel (Fig. 10C), style elongate, with a large, broad, inwardly-twisted apex (Fig. 10D, F), median sclerite inverted-Y-shaped (Fig. 10H) and paramere with a single hook (Fig. 10I), pupal gill with four slender filaments (Fig. 11F), and larval mandible with supernumerary serrations (Fig. 12B).

This new species appears to be somewhat related to *S. (N.) qiaolaoense* Chen and *S. (N.) qinqshuiense* Chen, both described from Guizhou Province, China (Chen, 2001) and *S. (N.) yushangense* Takaoka, described from Taiwan (Takaoka, 1979) in having the pupal gill with four filaments, one of which is longer and thicker than the others (Fig. 11F) as well as the cocoon with an anterodorsal projection (Fig. 11M, N). However, this new species

is distinguished from all these known species in the male by the number of horizontal rows of large upper eye-facets which is 23 in this new species, 16 in both *S. (N.) qiaolaoense* and *S. (N.) qinqshuiense*, and 17 in *S. (N.) yushangense*. This new species is also distinguished from two Chinese known species by the ventral plate with two depressions on the posterior margin (Fig. 10C) (posterior margin of the ventral plate of the two Chinese species is straight, without such depression), and the long anterodorsal projection of the cocoon (Fig. 11M, N) (anterodorsal projection of the cocoon is short in both Chinese species), and from *S. (N.) yushangense* by the absence of the larval accessory sclerite. This new species is also similar to *S. (N.) gejjelense* Dzhabarov from Azerbaidzhan (Rubtsov, 1956) in the arrangement of pupal gill filaments but differs from the latter by the larval rectal papilla with secondary lobules (rectal papilla is simple in *S. (N.) gejjelense*).

Simulium (N.) burmense Takaoka, which was described only from females collected in Myanmar (Takaoka, 1989), differs from this new species by the antenna which is dark brown except the orange scape and pedicel, as well as all the femora which are yellow except the dark brown apical caps.

***Simulium (Nevermannia) bumthangense*
Takaoka and Somboon sp. nov.**

DESCRIPTION. Male. Body length 2.8 mm. **Head.** Slightly wider than width of thorax. Upper eye consisting of 16 or 17 vertical columns and 17 horizontal rows of large facets. Face dark brown, grayish-white pruinose. Clypeus dark brown, grayish-white pruinose, moderately covered with yellow long hairs except mediolongitudinal portion widely bare. Antenna composed of scape, pedicel and 9 flagellomeres, dark brown except base of 1st flagellomere dark yellow; 1st flagellomere somewhat elongate, 2.06 times as long as 2nd one. Maxillary palp composed of 5 segments, light to medium brown, proportional lengths of 3rd, 4th, and 5th segments 1.00:0.87:1.83; sensory vesicle (Fig. 13A) small, ellipsoidal,

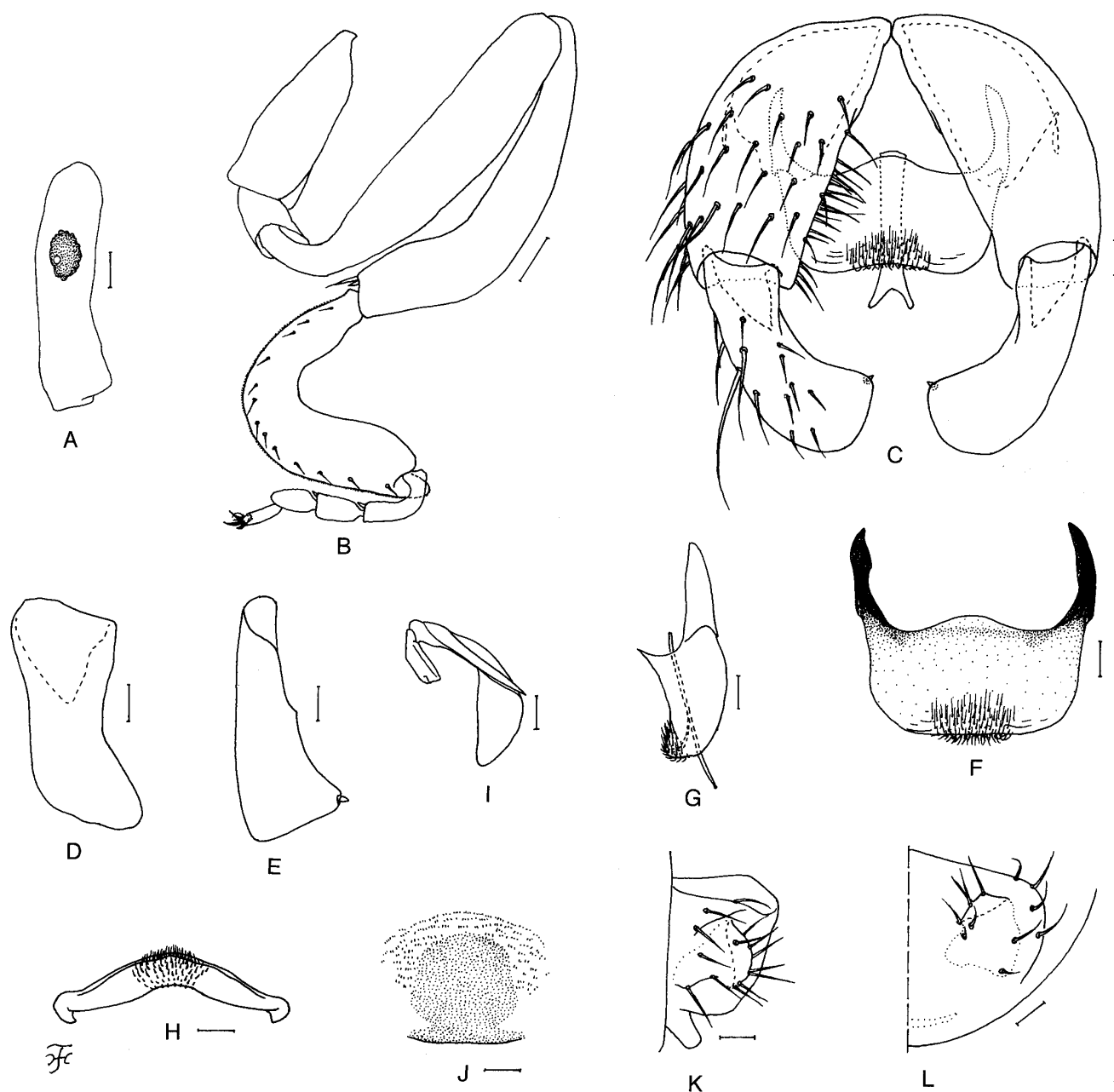


Fig. 13. Male of *Simulium* (*Nevermannia*) *bumthangense* sp. nov. A, 3rd segment of maxillary palp with sensory vesicle (right side; front view); B, hind leg (left side; outer view); C, coxites, styles, ventral plate and median sclerite *in situ* (ventral view); D and E, style (right side; D, ventrolateral view; E, medial view); F, ventral plate (ventral view); G, ventral plate and median sclerite *in situ* (lateral view); H, ventral plate (end view); I, paramere (left side; end view); J, aedeagal membrane and dorsal plate *in situ* (end view); K and L, 10th abdominal segment and cercus *in situ* (K, right side and lateral view; L, left side and end view). Scale bars. 0.1 mm for B; 0.02 mm for A and C–L.

0.21 times as long as 3rd segment, with very small opening. **Thorax.** Scutum dark brown to brownish-black except anterior calli medium brown, gray-pruinose and shiny on each shoulder, narrow area along each lateral margin and prescutellar area at certain angle of light, densely covered with golden-yellow short hairs interspersed with several same colored and few dark brown upright longer hairs on pre-

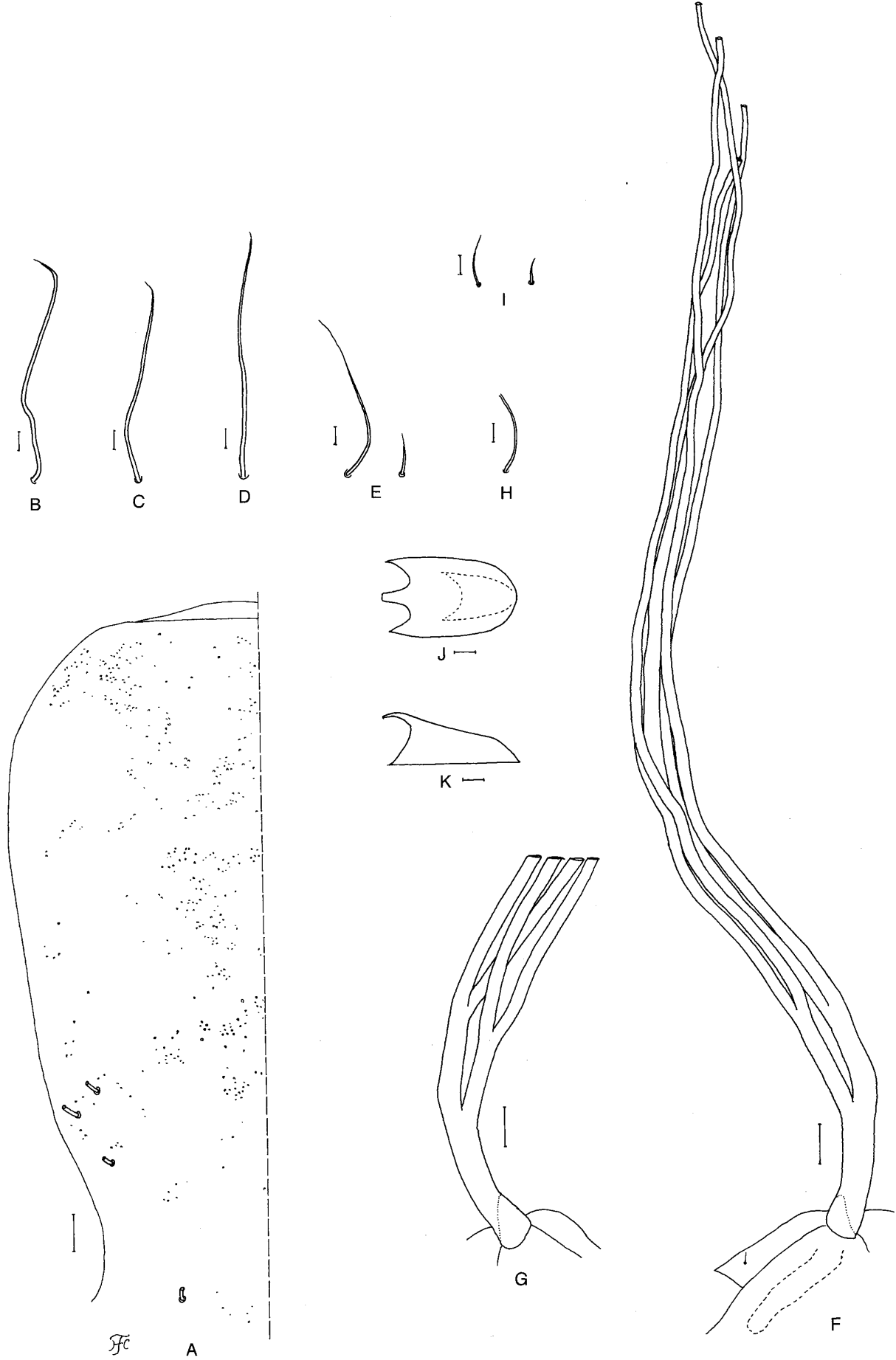
scutellar area. Scutellum light brown, with golden-yellow short to long hairs and few dark long upright hairs. Postnotum dark brown, gray pruinose, shiny at certain angle of light, bare. Pleural membrane bare. Katepisternum longer than depth, dark brown, gray pruinose, shiny at certain angle of light, and bare. **Legs.** Foreleg: coxa yellow; trochanter dark yellow to light brown; femur dark yellow except apical

cap dark brown; tibia dark brown to brownish-black except medial portion of outer surface widely light brown; tibia densely covered with yellow hairs on outer surface of basal 3/4; tarsus brownish-black; basitarsus somewhat dilated, 9.22 times as long as its greatest width. Midleg: coxa medium brown except posterior surface brownish-black; trochanter medium brown; femur dark yellow except apical cap dark brown; tibia dark brown except basal tip and wide median portion light brown; tibia moderately covered with yellow hairs on basal 2/3 of posterior surface; tarsus brownish-black. Hind leg (Fig. 13B): coxa light to medium brown; trochanter dark yellow to light brown; femur dark yellow except apical cap dark brown; tibia dark brown except basal tip and wide median portion light brown; tibia moderately covered with yellow hairs on basal 3/4 of posterior surface; tarsus light brown except basal 2/5 of 2nd segment white; basitarsus enlarged, 1.02 and 0.90 times as wide as greatest width of hind tibia and femur respectively; calcipala well developed, 0.90 times as long as its basal width, and 0.35 times as wide as greatest width of basitarsus; pedisulcus not well defined. **Wing.** Costa with dark spinules and hairs except basal portion mostly covered with yellow hairs. Subcosta bare. Hair tuft on stem vein dark brown. Basal portion of radial vein fully haired. R_1 with dark spinules and hairs. R_2 with dark hairs only. Basal cell and basal median cell absent. **Abdomen.** Basal scale light brown, with fringe of dark long hairs. Dorsal surface of abdominal segments dark brown, moderately covered with dark short and long hairs except few anterior segments also covered with yellow hairs. **Genitalia.** Coxite in ventral view (Fig. 13C) rectangular, 2.08 times as long as wide. Style in ventrolateral view (Fig. 13D) constricted medially, 1.90 times as long as its basal width, and 0.85 times as long as coxite; style in medial view (Fig. 13E) boot-shaped, with inwardly directed triangular flange with small spine at its apex; ventral plate in ventral view (Fig. 13C)

transverse, plate-like, very slightly tapered posteriorly, 0.57 times as long as wide, with posterior margin slightly depressed medially (though apparently straight when ventral plate is slightly inclined and viewed, Fig. 13F), and with minute setae medially on posterior 1/5 of ventral surface; arms well sclerotized, directed slightly outwardly, then directed forward or slightly inwardly; ventral plate in lateral view (Fig. 13G) slightly produced ventrally near posterior margin, and with arm directed forward; ventral plate in end view (Fig. 13H) slightly rounded ventrally, with ventral margin undulate, and setose medially on posterior surface. Median sclerite in ventral view (Fig. 13C) arising just before anterior margin of ventral plate, and narrow, nearly parallel-sided, and forked apically, and in lateral view (Fig. 13G) lying very close to dorsal surface of ventral plate. Paramere in end view (Fig. 13I) narrow, with 1 long parameral hook directed laterally, and with small isolated sclerotized plate near base of hook. Aedeagal membrane in end view (Fig. 13J) moderately covered with microsetae, and dorsal plate in end view (Fig. 13J) strongly sclerotized, widely extended ventrally in middle. Abdominal segment 10 (Fig. 13K, L) with 1 or 2 hairs on or near posterolateral margin of ventral surface and 2 hairs on lateral surface on each side. Cercus (Fig. 13K, L) slightly darkened, rounded, and with 8 or 11 hairs.

Pupa. Body length (excluding gill filaments) 2.8 mm. **Head.** Integument (Fig. 14A) light yellowish-brown, sparsely covered with minute tubercles on frons; antennal sheath smooth; frons with 3 simple long trichomes (Fig. 14B) on each side; face with 1 simple long trichome (Fig. 14C) on each side. **Thorax.** Integument light yellowish-brown, very sparsely to sparsely covered with small tubercles, and on each side with 3 simple long trichomes mediodorsally (Fig. 14D), 2 simple trichomes (1 medium-long, 1 short) ventrolaterally (Fig. 14E); 2 anterolateral, 1 posterolateral and 1 of 3 ventrolateral trichomes lost. Gill (Fig. 14F, G)

Fig. 14. Pupa of *Simulium (Nevermannia) bumthangense* sp. nov. A, frons and part of face sparsely covered with minute tubercles (right half); B, frontal trichome; C, facial trichome; D, mediodorsal trichomes; E, ventrolateral trichomes; F, gill filaments (left side; lateral view); G, basal portion of gill filaments showing stalks of dorsal and ventral pairs of different lengths; H, seta (broken) on dorsal surface of abdominal segment 1; I, short seta and very short seta on dorsal surface of abdominal segment 2; J and K, cocoon (J, dorsal view; K, lateral view). Scale bars. 0.5 mm for J and K; 0.1 mm for F and G; 0.04 mm for A; 0.02 mm for B-E, H and I.



with 4 slender thread-like filaments, longer than pupal body, arranged vertically in dorsal and ventral pairs arising from common basal stalk of moderate length; common basal stalk thicker than interspiracular trunk, with transparent swollen portion ventrally, and longer than stalks of dorsal and ventral pairs; stalk of ventral pair slightly longer or shorter than stalk of dorsal pair; dorsal filament of dorsal pair very slightly thicker than 3 other filaments; all filaments medium brown except basal 3/4 of common basal stalk yellow, probably subequal in length to one another (all tips lost, therefore, exact length of each filament not known though remaining portions of filaments 2.8–3.0 mm long), lying close together, directed forward, gradually tapered toward apex, furnished with annular ridges and furrows, and densely covered with minute tubercles on outer surface. **Abdomen.** Dorsally, segments 1 and 2 weakly sclerotized, medium brown, very weakly tuberculate; segment 1 with 1 slender seta (tip lost, probably medium-long) (Fig. 14H) on each side; segment 2 with 1 slender short seta and 5 very short setae (Fig. 14I) on each side; other features of dorsal surface and all features of ventral surface nearly as in preceding species except dorsal surface of segment 5 with comb-like groups of minute spines as well as spine-combs in transverse rows on each side. **Cocoon** (Fig. 14J, K). Wall-pocket-shaped, neatly woven, thin except anterior margin thickly woven, and extending ventrolaterally, with long narrow anterodorsal projection slightly bent downward; floor woven on posterior 1/2; individual threads invisible; 3.1 mm long by 2.0 mm wide.

Female and mature larva. Unknown.

TYPE SPECIMEN. Holotype pharate male (with its associated pupal exuviae and cocoon), collected from a moderately-flowing stream (width 2 m, depth 10–20 cm, water temperature 22°C, exposed to sun, altitude 2,570 m; 27°32'20"N, 90°48'26"E) in a sparsely forested area, Dungmithang, Bumthang, Bhutan, 5. IX. 2007.

ECOLOGICAL NOTE. The pupa of this new species was collected from a grass stalk, together with *S. (S.) pradyai* sp. nov.

ETYMOLOGY. The specific name *bumthangense* refers to the name of the locality, Bumthang, where this new species was collected.

REMARKS. *Simulium (N.) bumthangense* sp. nov. is also assigned to the *vernum* species-group within the subgenus *Nevermannia* by the male ventral plate lamellate, without a median keel (Fig. 13C), style elongate, with a large, broad, inwardly-twisted apex (Fig. 13E), median sclerite inverted-Y-shaped (Fig. 13C), paramere with a single hook (Fig. 13I) and pupal gill with four slender filaments (Fig. 14F, G).

This new species differs from *S. (N.) thrimshinglaense* sp. nov. in the male by the smaller number of large eye-facets, the clypeus covered with yellow hairs alone and the ventral plate with a posterior margin nearly straight or gently concave medially (Fig. 13C, F) and in the pupa by the frons sparsely covered with minute tubercles (Fig. 14A) and the gill filaments longer than the pupal body (Fig. 14F). This new species is also distinguished from the following six known species reported from the Oriental Region which have the pupal gill with four filaments of almost the same length and thickness coupled with the cocoon with a long anterodorsal projection: *S. (N.) cangshanense* Xue and *S. (N.) cheni* Xue both from Yunnan Province, China (Xue, 1993) have a different shape of the ventral plate (i.e., posterior margin convex); *S. (N.) caudisclerum* Takaoka and Davies from Peninsular Malaysia and Thailand (Takaoka and Davies, 1995) has a smaller number of large upper eye-facets (i.e., 14 vertical columns and 15 horizontal rows), and the clypeus covered mostly with brown hairs; *S. (N.) purii* Datta from India (Datta, 1973) has a smaller number of large upper eye-facets (i.e., 15 vertical columns and 15 horizontal rows) and the ventral plate more widely setose on the posterior margin (i.e., not only medially but also submedially); *S. (N.) tosariense* Edwards

from Java (Takaoka and Davies, 1996) has the larger number of large upper eye-facets (i.e., 19 vertical columns and 22 horizontal rows), the clypeus covered mostly with brown hairs, and the pupal gill with a short common basal stalk; *S. (N.) tjibodense* Edwards from Java (Takaoka and Davies, 1996) has the ventral plate with the basal arms widely divergent.

There is a possibility that this new species is conspecific with *S. (N.) burmense* described only from females collected in Myanmar (Takaoka, 1989).

***Simulium (Simulium) demolaense*
Takaoka and Somboon sp. nov.**

DESCRIPTION. Male. Body length 2.8 mm.

Head. Width subequal to that of thorax. Upper eye consisting of large facets in 17 vertical columns and in 18 horizontal rows. Clypeus brownish-black, thickly white pruinose, covered with dark brown hairs along and near lateral margins (most of central portion bare). Antenna composed of scape, pedicel and 9 flagellomeres, light to medium brown except scape, base of pedicel, and base of 1st flagellomere yellow; 1st flagellomere elongate, 1.93 times as long as 2nd one. Maxillary palp dark brown, composed of 5 segments with proportional lengths of 3rd, 4th, and 5th segments 1.0:1.25:2.42; 3rd segment (Fig. 15A, B) of normal size; sensory vesicle small (0.18–0.22 times as long as 3rd segment), globular or ellipsoidal, and with very small opening.

Thorax. Scutum brownish-black to black, with white pruinose pattern, i.e., anterior pair of rectangular spots on shoulders extending posteriorly along lateral margins and connected to large transverse spot entirely covering prescutellar area; these pruinose areas silvery or bluish iridescent when illuminated at certain angles of light; scutum uniformly and densely covered with golden-yellow recumbent short hairs interspersed with dark brown similar short hairs on anterior surface, and with dark brown long upright hairs on prescutellar area. Scutellum dark brown, shiny, white pruinose, with several dark long upright hairs as well as golden-yellow short hairs. Postnotum dark brown to brownish-black, shiny, gray pruinose, bare. Pleural membrane bare. Katepisternum

longer than deep, bare. **Legs.** Foreleg (Fig. 15C): coxa whitish-yellow; trochanter medium brown though base of posterior surface yellowish; femur medium brown with apical cap dark brown; tibia medium to dark brown except outer surface widely white, and sheeny when illuminated at certain angle of light; tarsus brownish-black, with moderate dorsal hair crest; basitarsus greatly dilated, 5.52 times as long as its greatest width. Midleg (Fig. 15D): coxa brownish-black; trochanter medium brown except base of outer surface yellowish; femur medium brown with apical cap dark brown; tibia yellowish-white on basal 2/5 or more, then gradually darkened toward apex and with apical cap medium brown; tibia sheeny on posterior surface of basal 1/2 or little more when illuminated at certain angle of light; tarsus medium brown except basal 1/4 of basitarsus yellowish. Hind leg (Fig. 15E): coxa brownish-black; trochanter yellow; femur medium brown except base yellow and apical cap brownish-black; tibia medium to dark brown except basal tip yellow and apical cap brownish-black; tarsus medium to dark brown except basal 2/5 or little more of basitarsus and basal 1/3 of 2nd segment yellow; basitarsus much enlarged, spindle-shaped, 3.68 times as long as its greatest width, and 0.89 and 0.96 times as wide as greatest widths of hind tibia and femur, respectively; calcipala small, slightly shorter than width at base; pedisulcus well marked. **Wing.** Length 2.0 mm; costa with dark spinules and hairs; subcosta bare; basal section of radial vein bare; R_1 with dark spinules and hairs; R_2 with hairs; hair tuft on stem vein dark brown; basal cell absent. **Abdomen.** Basal scale brownish-black, with fringe of dark long hairs. Dorsal surface of abdomen dark brown to brownish-black, with dark short hairs; segments 2 and 5–7 each with pair of silvery or bluish iridescent spots dorsolaterally, those on segment 2 connected broadly to each other in middle. **Genitalia.** Coxite in ventral view (Fig. 15F) nearly quadrate, covered with many stout hairs near posterior margin; coxite in lateral view (Fig. 15G) much wider than long. Style in ventral view (Fig. 15F) elongate, somewhat constricted at apical 1/3 and slightly widened apically, with apical spine; style in ventrolateral view (Fig. 15H) elongate, 3.35 times as long as its greatest width near base, with inner margin slightly sinuous, nearly parallel-sided from base to

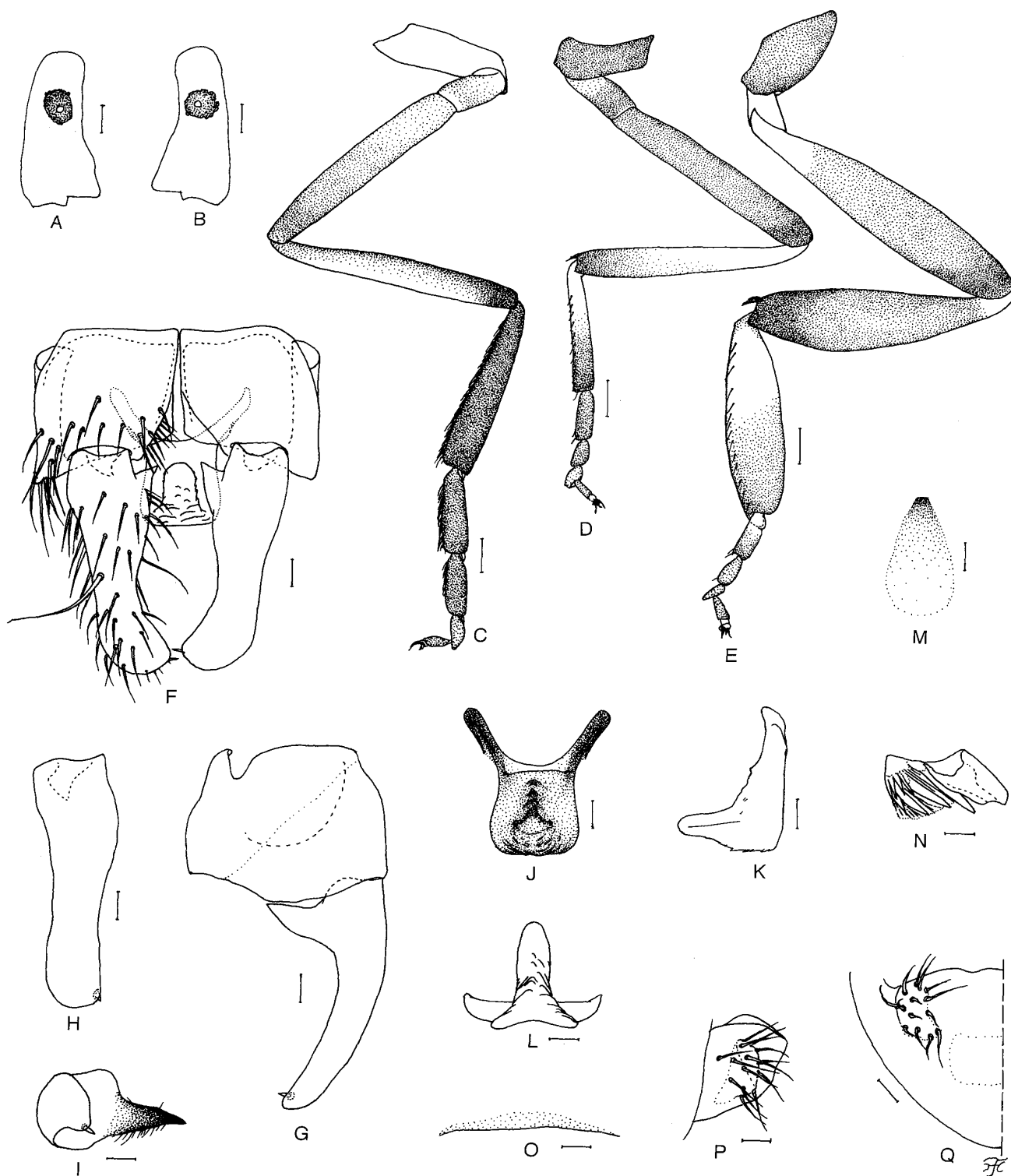


Fig. 15. Male of *Simulium* (*Simulium*) *demolaense* sp. nov. A and B, 3rd segment of maxillary palp with sensory vesicle (front view; A, right side; B, left side); C, foreleg (left side; outer view); D, midleg (left side; outer view); E, hind leg (left side; outer view); F, coxites, styles and ventral plate *in situ* (ventral view); G, coxite and style (right side; lateral view); H and I, style (right side; H, ventrolateral view; I, end view); J-L, ventral plate (J, ventral view; K, lateral view; L, end view); M, median sclerite (end view); H, ventral plate (end view); N, paramere (left side; end view); O, dorsal plate; P and Q, 10th abdominal segment and cercus *in situ* (right side; P, lateral view; Q, end view). Scale bars. 0.1 mm for C-E; 0.02 mm for A, B and F-Q.

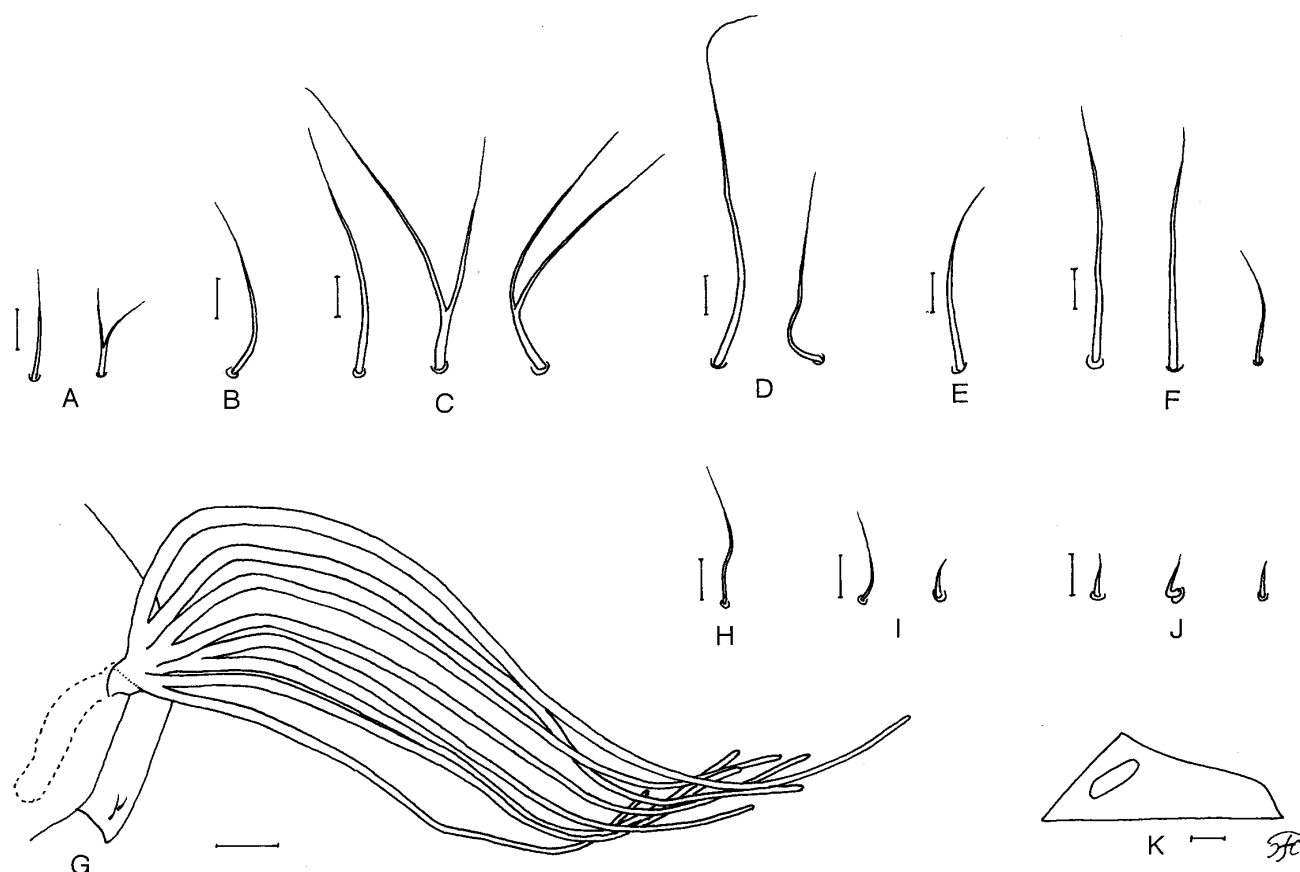


Fig. 16. Pupa of *Simulium* (*Simulium*) *demolaense* sp. nov. A, frontal trichomes; B, facial trichome; C-F, thoracic trichomes (C, mediodorsal; D, anterolateral; E, posterolateral; F, ventrolateral); G, gill filaments (right side; lateral view); H, medium-long seta on dorsal surface of abdominal segment 1; I, short seta and very short seta on dorsal surface of abdominal segment 2; J, short spinous setae on ventral surface of abdominal segment 4; K, cocoon (lateral view). Scale bars. 0.5 mm for K; 0.1 mm for G; 0.01 mm for A-F and H-J.

basal 1/3, narrowed to little beyond basal 2/3, then nearly parallel-sided or slightly widened toward apex; style in lateral view (Fig. 15G) spatulate dorsoventrally, 1.56 times as long as coxite, with long horn-like basal protuberance pointed dorsally which has no spines on anterior surface; style in end view (Fig. 15I) with basal protuberance almost bare on dorsal surface and setose on ventral surface except apex bare. Ventral plate in ventral view (Fig. 15F, J) with base nearly rectangular (though somewhat narrowed basally, and rounded on each posterolateral corner), with 3 setae on ventral surface; arms directed forward and outward diverging from each other at angle of 80 degrees; ventral plate in lateral view (Fig. 15K) with serrated posterior margin; ventral plate in end view (Fig. 15L) having several teeth in irregular rows on posterior surface except apical 1/2 of elliptical process smooth. Median sclerite (Fig. 15M) plate-like, widened from

base toward near apex, with round apex, brown basally, but not so well sclerotized apically. Paramere (Fig. 15N) with 4 distinct large hooks decreasing in length from base to apex, together with few smaller hooks near apex. Aedeagal membrane short, moderately covered with minute setae, and with weakly sclerotized dorsal plate (Fig. 15O). Abdominal segment 10 (Fig. 15P, Q) without any distinct hair on ventral and lateral surface. Cercus (Fig. 15P, Q) small, rounded, with 12 or 14 distinct hairs.

Pupa. Body length 3.0 mm. **Head.** Integument including antennal sheaths yellow to dark yellow, densely and elaborately covered with round tubercles (except apical 2/3 of antennal sheath almost bare); frons with 2 pairs of simple or bifid slender short trichomes (Fig. 16 A); face with pair of simple medium-long trichomes (Fig. 16B). **Thorax.** Integument yellow to dark yellow, densely and elaborately cov-

ered with small round tubercles; thorax on each side with 3 long somewhat stout trichomes (1 simple, 2 bifid on right side, 2 simple, 1 bifid on left side) mediodorsally (Fig. 16C), 2 simple trichomes (1 medium-long, 1 long and somewhat stout) anterolaterally (Fig. 16D), 1 simple medium-long somewhat stout trichome posterolaterally (Fig. 16E), and 3 simple trichomes (2 long and somewhat stout, 1 short) ventrolaterally (Fig. 16F). Gill (Fig. 16G) with 8 slender thread-like short filaments in 4 pairs (1 dorsal, 2 middle and 1 ventral) arising from very short common basal stalk; all pairs short-stalked, and stalk of dorsal pair directed upward and forward forming nearly right angle to stalk of ventral pair when viewed laterally; dorsal filament of dorsal pair longest (about 1.6 mm long), ventral filament of ventral pair shortest (about 1.0 mm long), and other filaments intermediate in length (1.1–1.4 mm); relative thickness of 8 filaments from dorsal to ventral when basal portions were compared 1.1 : 0.9 : 0.8 : 0.8 : 0.8 : 0.8 : 0.7 : 0.7; all filaments light to medium brown, tapered toward apex, with distinct annular ridges and furrows forming definite reticulate surface patterns, and densely covered with minute tubercles of different sizes (larger ones on ridges and smaller ones on interridge spaces). **Abdomen.** Dorsally, segment 1 weakly sclerotized, light ochreous, with 1 simple slender short seta (Fig. 16H) on each side; segment 2 transparent, with 1 simple slender short seta and 5 spinous very short setae (Fig. 16I) on each side; segments 3 and 4 transparent, each with 4 distinct simple hooks and 1 simple spinous short seta on each side; segments 5, 6, 7 and 9 transparent and lacking spine-combs; segment 8 with distinct spine-combs in transverse row; segments 6–8 with comb-like groups of minute spines on each side; segment 9 without terminal hooks. Ventrally, segments 3–9 transparent, each (except segment 9) with comb-like groups of minute spines; segment 4 with 3 spinous very short setae (Fig. 16J) on each side; segment 5 with pair of bifid stout hooks submedially and few simple short setae on each side; segments 6 and 7 each with pair of bifid inner and simple outer stout hooks somewhat separated from each other, and few simple short setae on each side. Grapnel-shaped hooklets absent on each side of segment 9. **Cocoon** (Fig. 16K). Wall-pocket-shaped, medium brown, thickly woven, with large anterolateral window (on right side,

window medially divided into 2 spaces by thread) on each side, not extending ventrolaterally; individual threads invisible; 3.7 mm long by 1.4 mm wide.

Female and Mature larva. Unknown.

TYPE SPECIMEN. Holotype male (with its associated pupal exuvia and cocoon), reared from a pupa collected from a moderately flowing stream (width 1.5 m, depth 10 cm, water temperature 24°C, exposed to sun, altitude 501 m) in a densely forested area in Demola, Deothang, Samdrup, Jongkhar, Bhutan, 26. VIII. 2007.

ECOLOGICAL NOTES. The pupa of *S. (S.) demolaense* sp. nov. was collected from a fallen tree branch in the water. An associated species was *S. (S.) deothangense* sp. nov.

ETYMOLOGY. The specific name *demolaense* refers to the name of the locality, Demola, where this new species was collected.

REMARKS. According to the key (Takaoka, 2003), *S. (S.) demolaense* sp. nov. is assigned to the *multistriatum* species-group of the subgenus *Simulium* in that it has the male style with a long basal protuberance (Fig. 15G), the ventral plate with toothed posterior margin (Fig. 15K, L), and the pupal gill with eight filaments arranged in pairs (Fig. 16G).

This new species is similar to *S. (S.) novolineatum* Puri described from India (Puri, 1932b, 1933) in that the ventral plate is almost bare (with only a few minute setae on the anterior surface) and bears irregularly arranged transverse wrinkle-like serrations on the posterior surface, but is distinguished from the latter species by the medium brown mid femur (Fig. 15D) (grayish-yellow in *S. (S.) novolineatum*), the medium to dark brown hind tibia except the yellow basal tip (Fig. 15E) (the basal 1/3 is pale yellow and the rest is black in *S. (S.) novolineatum*), and the gill filaments of which the stalks of the

dorsal and ventral pairs are lying at a right angle when viewed from the side (Fig. 16G) (at an obtuse angle in *S. (S.) novolineatum*). Three other related known species of the *multistriatum* species-group from India, i.e., *S. (S.) barraudi*, *S. (S.) dentatum* and *S. (S.) digitatum*, all described by Puri (1932b), have a different ventral plate in which the posterior surface is smooth or has well-defined teeth in two vertical rows. This new species is distinguished from *S. (S.) hillycum* Maskey described from Nepal (Maskey, 1989) by the darker mid and hind femora (Fig. 15D, E) (mostly yellowish in *S. (S.) hillycum* according to the figures in the original description). No information is available on the presence or absence of minute setae on the surface of the ventral plate of *S. (S.) hillycum*.

***Simulium (Simulium) deothangense*
Takaoka and Somboon sp. nov.**

DESCRIPTION. Female. Body length 2.8 mm. **Head.** Narrower than thorax. Frons black, bluish shiny, with several dark long stout hairs along each lateral margin and several similar hairs just above lower margin; frontal ratio 1.40:1.00:1.65; frons-head ratio 1.00:4.48. Fronto-ocular area (Fig. 17A) well developed, short, directed laterally and slightly upward. Clypeus black, white pruinose, silvery or bluish iridescent when illuminated, moderately covered with dark long stout hairs except upper 3/4 widely bare medially. Labrum 0.71 times as long as clypeus. Antenna composed of scape, pedicel and 9 flagellomeres, ochreous on scape, pedicel, and 1st to 3rd flagellomeres, and medium brown on rest of flagella in front view. Maxillary palp with 5 segments, light to dark brown, proportional lengths of 3rd, 4th, and 5th segments 1.00:1.17:2.24; 3rd segment (Fig. 17B) of normal size; sensory vesicle (Fig. 17B) large, oblong (0.41 times as long as 3rd segment) having medium-sized opening near apex. Maxillary lacinia with 13 or 14 inner and 13 outer teeth. Mandible with 24 or 25 inner and 12 or 14 outer teeth. Cibarium (Fig. 17C) with blunt median projection on posterior margin and without any minute processes near base of median projection. **Thorax.** Scutum brownish-black except anterolateral calli light

brown, shiny, densely covered with golden-yellow recumbent short hairs interspersed with medium brown similar short hairs on anterior surface, and with several dark brown long upright hairs on prescutellar area; when illuminated in front and viewed dorsally, scutum thickly white pruinose, with 5 non-pruinose longitudinal vittae (1 narrow medial vitta, 2 wider submedial vittae and 2 wider sublateral vittae though sublateral vittae somewhat wider than submedial ones), all vittae united with broad transverse band on prescutellar area; when illuminated from behind, scutum having reversed color pattern. Scutellum medium to dark brown, covered with dark brown upright long hairs as well as golden-yellow short hairs. Postnotum dark brown to brownish-black, shiny, gray pruinose, bare. Pleural membrane bare. Katepisternum longer than deep, bare. **Legs.** Foreleg (Fig. 17D): coxa and trochanter whitish-yellow; femur whitish-yellow except apical cap light brown; tibia white except apical cap brownish-black; tibia sheeny widely on outer surface when illuminated at certain angle of light; tarsus brownish-black, with moderate dorsal hair crest; basitarsus greatly dilated, 4.32 times as long as its greatest width. Midleg (Fig. 17E): coxa brownish-black; trochanter whitish-yellow except part of outer surface slightly darkened; femur whitish-yellow on little more than basal 1/2, light to medium brown on rest; tibia white except apical tip medium brown; tibia sheeny widely on posterior surface when illuminated at certain angle of light; tarsus medium brown except basal 3/5 of basitarsus yellowish-white. Hind leg (Fig. 17F): coxa dark brown; trochanter whitish-yellow; femur whitish-yellow on little less than basal 1/2, slightly darkened toward apex, with apical cap dark brown; tibia white to yellowish-white with apical cap dark brown; tibia sheeny widely on posterior surface when illuminated at certain angle of light; tarsus dark brown except basal 2/3 of basitarsus, and basal 1/2 of 2nd segment white; basitarsus nearly parallel-sided, 5.56 times as long as wide, and 0.75 and 0.64 times as wide as greatest widths of hind tibia and femur, respectively; calcipala moderately developed, 0.69 times as long as basal width, and 0.36 times as wide as greatest width of basitarsus; pedisulcus well developed at basal 1/3 of 2nd tarsal segment. All tarsal claws

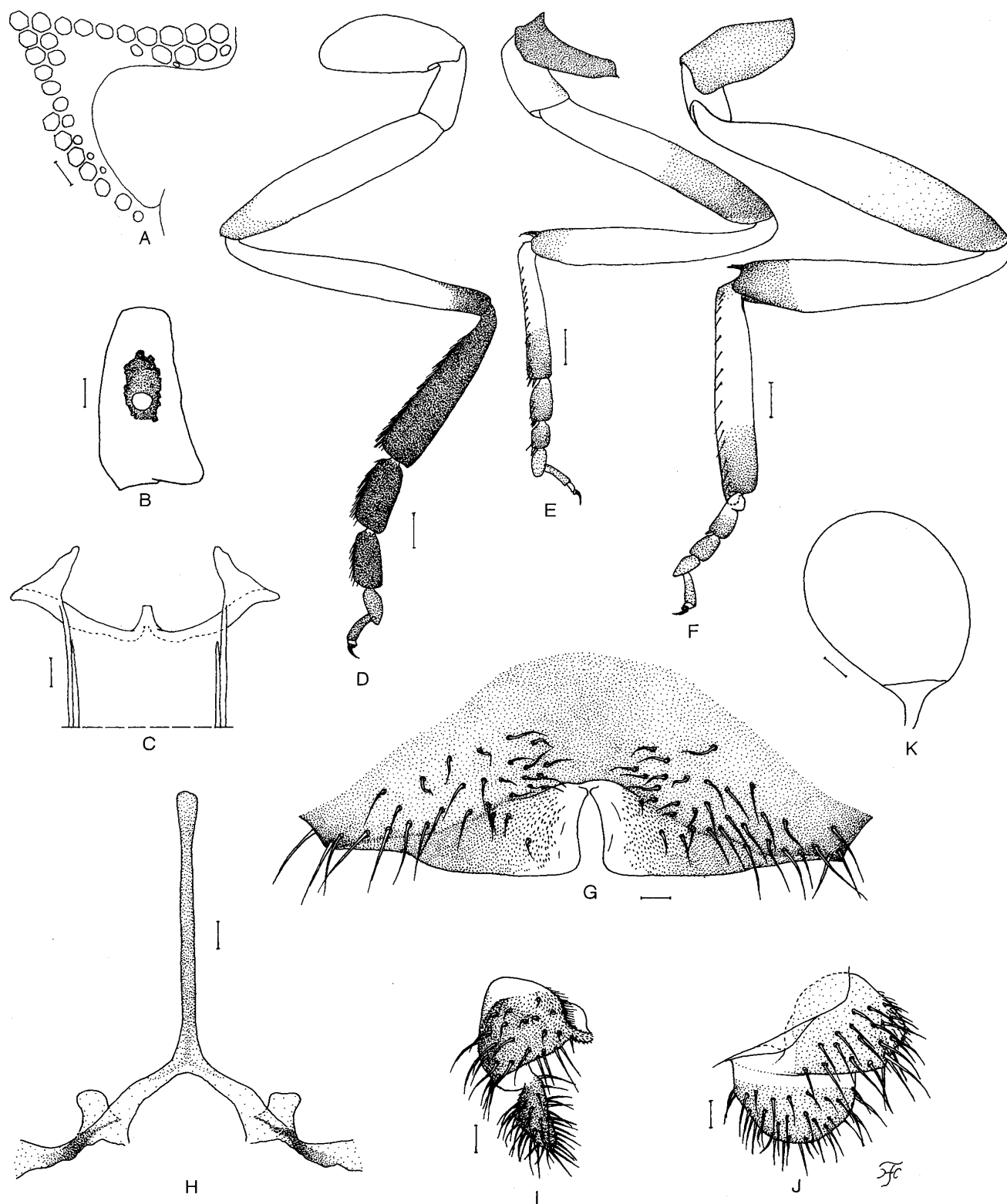


Fig. 17. Female of *Simulium* (*Simulium*) *deothangense* sp. nov. A, fronto-ocular area (right side; front view); B, 3rd segment of maxillary palp with sensory vesicle (right side; front view); C, upper portion of cibarium; D, foreleg (left side; outer view); E, mid leg (left side; outer view); F, hind leg (left side; outer view); G, 8th sternite and ovipositor valves *in situ*; H, genital fork; I and J, paraproct and cercus *in situ* (right side; I, ventral view; J, lateral view); K, spermatheca. Scale bars. 0.1 mm for D-F; 0.02 mm for A-C and G-K.

simple. **Wing.** Length 2.4 mm. Costa with dark spinules and hairs; subcosta haired except near apex bare; basal section of radial vein bare; R_1 with dark spinules and hairs; R_2 with hairs; hair tuft on stem vein dark brown; basal cell absent. **Abdomen.** Basal scale medium brown, with fringe of long hairs. Dorsal surface of abdomen dark brown to brownish-black except basal 4/5 of 2nd segment yellowish-white, with short dark hairs; tergite 2 shiny, white iridescent when illuminated, and tergites 6–8 shiny. Ventral surface of 7th segment with large weakly sclerotized sternal plate medially. **Genitalia.** Sternite 8 (Fig. 17G) bare medially, with 28 or 31 dark medium-long to long stout hairs on each lateral surface. Ovipositor valves (Fig. 17G) triangular, membranous, each moderately covered with microsetae and 3 dark medium-long hairs, except portion along inner margin widely bare, so thin and transparent that it is difficult to discern inner margins. Genital fork (Fig. 17H) of inverted-Y form, with narrow well sclerotized stem; arms of moderate width, each with distinct short and wide projection having blunt apex directed anterodorsally. Paraproct in ventral view (Fig. 17I) nearly quadrate, with narrow tip medially, strongly sclerotized on outer surface but unsclerotized on anterior and inner surface, densely covered with minute setae and with 24 or 26 short to medium-long hairs on lateral and ventral surface except anterior portion widely bare; inner surface with 5 or 6 short sensilla; paraproct in lateral view (Fig. 17J) moderately protruded ventrally beyond ventral margin of cercus, and 1.44 times as long as cercus. Cercus in lateral view (Fig. 17J) short, rounded posteriorly, 0.59 times as long as wide, and with numerous short to medium-long hairs. Spermatheca (Fig. 17K) nearly ovoid, 1.17 times as long as wide, well sclerotized except small portion of juncture with duct unsclerotized, with no defined surface patterns, and with internal setae; accessory ducts subequal in thickness to each other, and slightly thicker than major duct.

Pharate Male. Only following features were observed. Body length 2.8 mm. **Head.** Width subequal to that of thorax. Upper eye consisting of large facets in 18 vertical columns and in 19 horizontal rows. Clypeus dark brown, thickly white pruinose, moderately covered with long hairs except central portion of upper 1/2 bare. Antenna composed of scape, pedicel and

9 flagellomeres; color undeveloped; 1st flagellomere elongate, 1.77 times as long as 2nd one. Maxillary palp composed of 5 segments; 3rd segment (Fig. 18A, B) of normal size; sensory vesicle (Fig. 18A, B) small (0.20 times as long as 3rd segment), globular or ellipsoidal, and with medium-sized or large opening. **Thorax.** Scutum dark, with white pruinose pattern similar to that of *S. (S.) demolaense* sp. nov.; these pruinose areas silvery or bluish iridescent when illuminated at certain angles of light; scutum uniformly and densely covered with golden-yellow recumbent short hairs interspersed with dark brown similar short hairs on anterior surface, and with dark brown long upright hairs on prescutellar area. Scutellum with several dark long upright hairs as well as golden-yellow short hairs. Postnotum, pleural membrane and katepisternum as in female. **Legs.** Fore basitarsus moderately dilated, 5.13 times as long as its greatest width. Hind basitarsus enlarged; calcipala small, slightly shorter than width at base. **Wing.** As in female except subcosta bare. **Genitalia.** Coxite in ventral view (Fig. 18C) nearly quadrate, covered with many stout hairs near posterior margin. Style in ventral view (Fig. 18C) elongate, somewhat constricted at apical 1/3 and slightly widened apically, with apical spine; style in ventrolateral view (Fig. 18D) elongate, 3.11 times as long as its greatest width at basal 1/3, with inner margin sinuous, nearly parallel-sided from base to basal 1/3, narrowed to little beyond basal 2/3, then nearly parallel-sided or slightly widened toward apex; style in lateral view (Fig. 18E) spatulate dorsoventrally, 1.50 times as long as coxite, with long horn-like subbasal protuberance pointed dorsally which has no spines on anterior surface. Ventral plate in ventral view (Fig. 18C) with base nearly rectangular (though somewhat narrowed basally, and rounded on each posterolateral corner), with minute setae on ventral and anterior surface; arms directed forward and outward diverging from each other at angle of 50 degrees; ventral plate in lateral view (Fig. 18F) with serrated posterior margin; ventral plate in end view (Fig. 18G) having several teeth in 2 vertical rows on posterior surface except apical 1/2 of elliptical process smooth. Median sclerite, paramere, aedeagal membrane similar to those of *S. (S.) demolaense* sp. nov. Abdominal segment 10 without any distinct hair on ventral and lateral surface. Cercus small,

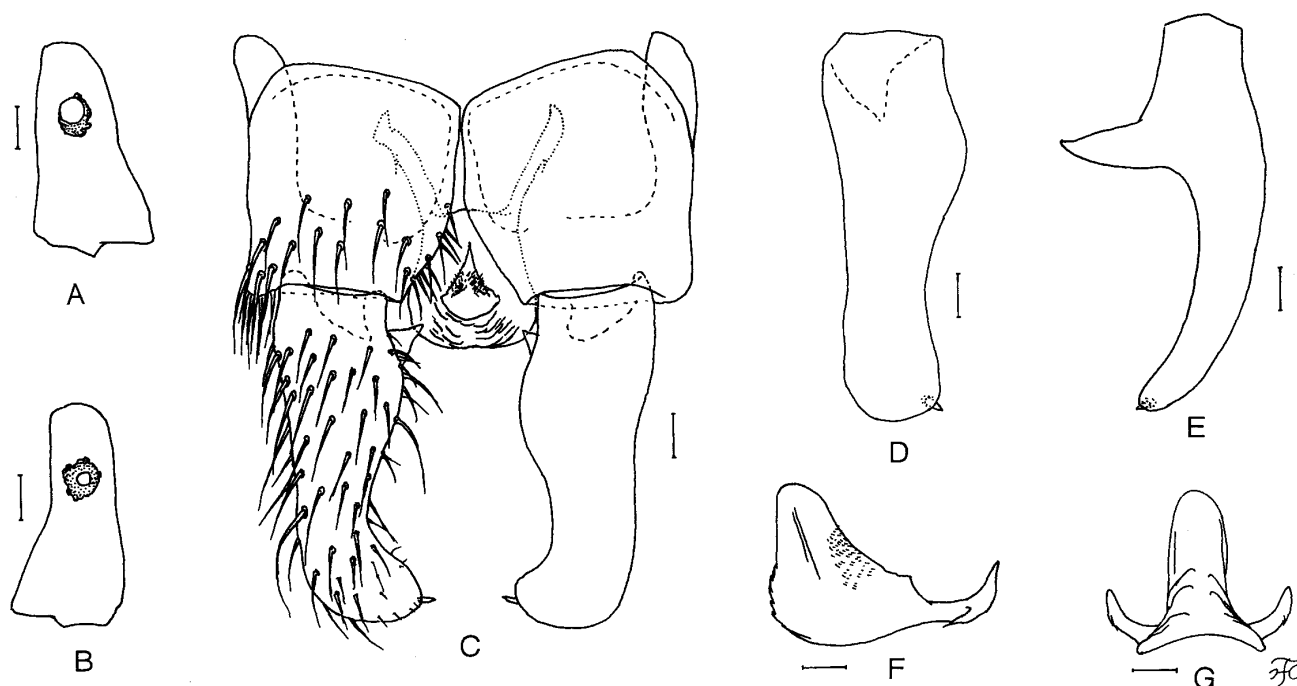


Fig. 18. Male of *Simulium* (*Simulium*) *deothangense* sp. nov. A and B, 3rd segment of maxillary palp with sensory vesicle (front view; A, right side; B, left side); C, coxites, styles and ventral plate *in situ* (ventral view); D and E, style (D, right side and ventrolateral view; E, left side and medial view); F and G, ventral plate (F, lateral view; G, end view). Scale bars. 0.02 mm for A–G.

rounded, with 9 or 11 distinct hairs.

Pupa. Body length 3.0 mm. **Head.** Integument including antennal sheaths yellow to dark yellow, densely and elaborately covered with round tubercles (except apical 2/3 of antennal sheath almost bare); frons with 2 pairs of simple slender short trichomes of different length (Fig. 19A); face with pair of simple medium-long trichomes (Fig. 19B). **Thorax.** Integument yellow to dark yellow, densely and elaborately covered with small round tubercles; thorax on each side with 3 trichomes (1 simple and medium-long or bifid, 2 bifid or trifold, long and somewhat stout) mediodorsally (Fig. 19C), 2 simple trichomes (1 long and somewhat stout, 1 medium-long) anterolaterally (Fig. 19D), 1 simple medium-long stout trichome posterolaterally (Fig. 19E), and 3 simple trichomes (2 long and somewhat stout, 1 short) ventrolaterally (Fig. 19F). Gill (Fig. 19G) with 8 slender thread-like short filaments in 4 pairs (1 dorsal, 2 middle and 1 ventral) arising from very short common basal stalk; all pairs short-stalked, and stalks of dorsal and ventral pairs widely diverged forming an obtuse angle of 120 degrees when viewed laterally; 2 filaments of dorsal pair longest (about 1.8 mm long), filaments of ventral pair and lower filaments of 2 middle pairs subequal in length and shortest

(1.0–1.2 mm long), and dorsal filaments of 2 middle pairs intermediate in length (1.4–1.6 mm); relative thickness of 8 filaments from dorsal to ventral when basal portions were compared 1.3 : 1.2 : 1.0 : 0.8 : 1.1 : 0.9 : 0.8 : 0.8; all filaments light yellow to light yellowish-brown, tapered toward apex, with distinct annular ridges and furrows forming definite reticulate surface patterns, and densely covered with minute tubercles of different sizes (larger ones on ridges and smaller ones on interridge spaces). **Abdomen.** Dorsally, segment 1 weakly sclerotized, light ochreous, with 1 simple slender short seta (Fig. 19H) on each side; segment 2 transparent, with 1 simple slender short seta and 5 spinous short setae (Fig. 19I) on each side; segments 3 and 4 transparent, each with 4 distinct simple hooks and 1 simple spinous short seta on each side; segments 5, 6, 7 and 9 transparent and lacking spine-combs; segment 8 with distinct spine-combs in transverse row; segments 6–8 with comb-like groups of minute spines on each side; segment 9 without terminal hooks. Ventrally, segments 3–9 transparent, each (except segment 9) with comb-like groups of minute spines; segment 4 with few slender minute setae on each side; segment 5 with pair of bifid stout hooks submedially and few simple short setae on each side; segments 6

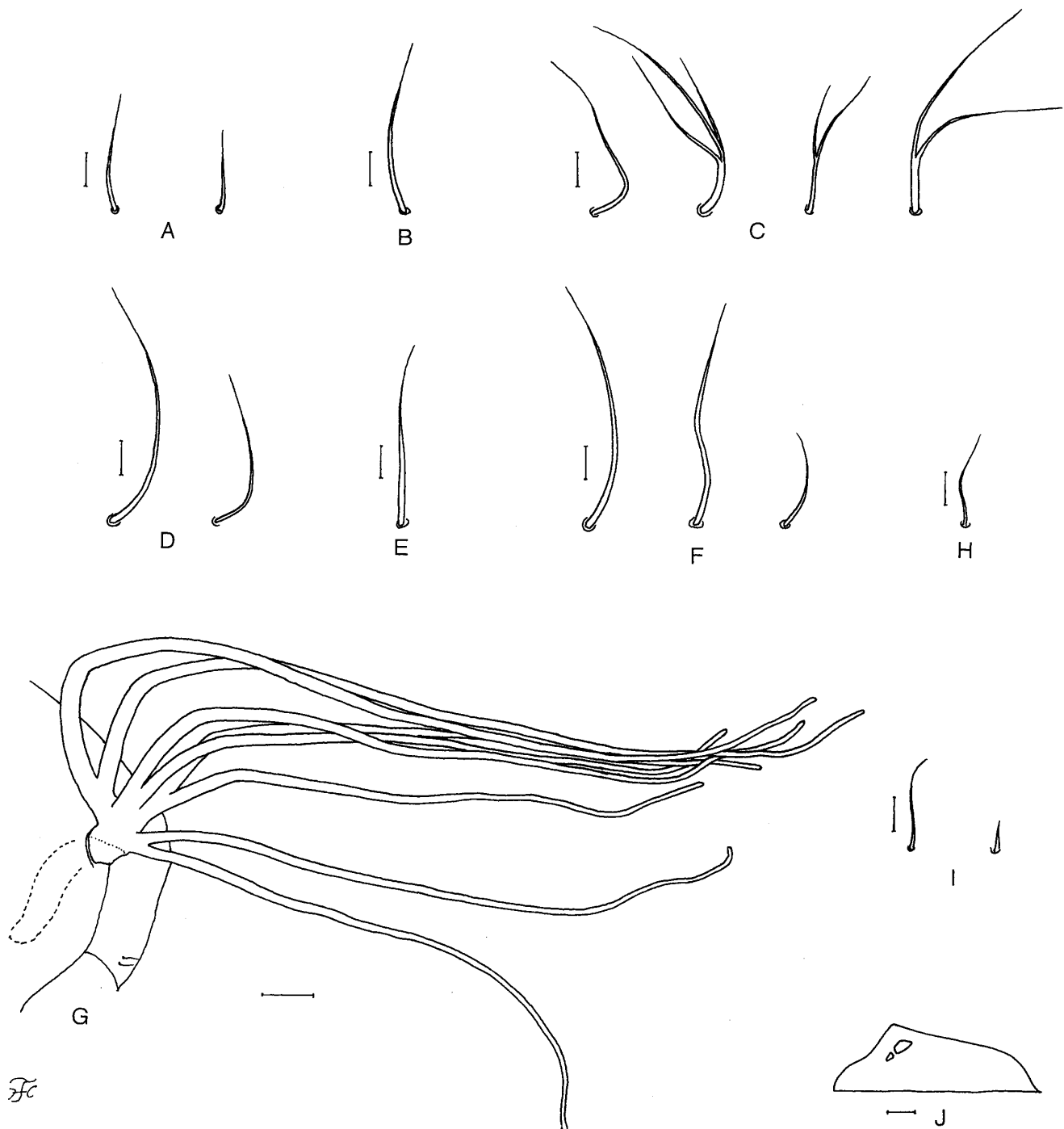


Fig. 19. Pupa of *Simulium* (*Simulium*) *deothangense* sp. nov. A, frontal trichomes; B, facial trichome; C-F, thoracic trichomes (C, mediodorsal; D, anterolateral; E, posterolateral; F, ventrolateral); G, gill filaments (right side; lateral view); H, short seta on dorsal surface of abdominal segment 1; I, short seta and very short seta on dorsal surface of abdominal segment 2; J, cocoon (lateral view). Scale bars. 0.5 mm for J; 0.1 mm for G; 0.01 mm for A-F, H and I.

and 7 each with pair of bifid inner and simple outer stout hooks somewhat separated from each other, and few simple short setae on each side. Grapnel-shaped hooklets absent on each side of segment 9. **Cocoon** (Fig. 19J). Wall-pocket-shaped, moderately woven though anterior margin thickly woven, light yellowish-

white, with anterolateral window variable in size from very small to medium, though always smaller than that of *S. (S.) demolaense* sp. nov. and often divided into 2 or 3 open spaces, and not extending ventrolaterally; individual threads invisible; 3.5–3.8 mm long by 1.2–1.4 mm wide.

Mature larva. Unknown.

TYPE SPECIMENS. Holotype female (with its associated pupal exuviae and cocoon), reared from a pupa collected at the same stream where *S. (S.) demoalense* sp. nov. was collected. Paratypes: 1 pharate male and 1 pupa, same data and date as those of the holotype.

ECOLOGICAL NOTES. The pupae of *S. (S.) deothangense* sp. nov. were collected from stalks of grasses in the water. An associated species was *S. (S.) demolaense* sp. nov.

ETYMOLOGY. The specific name *deothangense* refers to the name of the locality, Deothang, where this new species was collected.

REMARKS. *Simulium (S.) deothangense* sp. nov. is also assigned to the *multistriatum* species-group of the subgenus *Simulium* by having the scutum with five longitudinal vittae, simple claws in the female, the style with a long subbasal protuberance (Fig. 18E), the ventral plate with toothed posterior margin (Fig. 18C, F) in the male, and the gill with eight filaments (Fig. 19G) in the pupa.

This new species is distinguished from the preceding new species, *S. (S.) demolaense* sp. nov., by the male ventral plate with many minute setae (Fig. 18F), the pupal gill filaments widely divergent (Fig. 19G), and the weakly pigmented cocoon with a small anterolateral window on each side (Fig. 19J).

The divergent pupal gill filaments seem to relate this new species to *S. (S.) novolineatum*, *S. (S.) barraudi*, *S. (S.) dentatum* and *S. (S.) digitatum*, all from India (Puri, 1932b, 1933), *S. (S.) hillicum* from Nepal (Maskey, 1989) and *S. (S.) lampangense* Takaoka and Choochote from Thailand (Takaoka and Choochote, 2005). However this new species is distinguished from all four Indian related species by the ventral plate with many setae (Fig. 18F), from *S.*

(S.) hillicum and *S. (S.) lampangense* by the subbasal protuberance of the style without any spines on the anterior surface (Fig. 18E), and also from *S. (S.) hillicum* by the almost white female mid tibia (Fig. 17E) (the female mid tibia of *S. (S.) hillicum* is black according to the figure in the original description).

***Simulium (Simulium) rangjungense*
Takaoka and Somboon sp. nov.**

DESCRIPTION. Female. Body length 2.2 mm. **Head.** Narrower than width of thorax. Frons brownish-black to black, shiny, with several dark stout hairs along lateral margins; frontal ratio 1.33 : 1.00 : 1.18; frons-head ratio 1.0 : 3.59. Fronto-ocular area (Fig. 20A) moderately developed, directed laterally with round apex. Clypeus brownish-black to black, shiny, with scattered dark stout hairs marginally (widely bare medially). Labrum 0.52 times as long as clypeus. Antenna composed of scape, pedicel and 9 flagellomeres, medium brown except scape, pedicel and basal 1/2 or more of 1st flagellomere yellow in dorsal (or posterior) view (1st flagellomere entirely yellow in ventral or anterior view). Maxillary palp medium brown to brownish-black, composed of 5 segments with proportional lengths of 3rd, 4th, and 5th segments 1.00 : 1.07 : 2.35; 3rd segment (Fig. 20B) somewhat enlarged; sensory vesicle large, oblong, with rugged surface, 0.59–0.62 times as long as 3rd segment, with medium-sized round opening. Maxillary lacinia with 13 or 16 inner and 17 or 18 outer teeth. Mandible with 26 inner and 9 or 10 outer teeth. Cibarium (Fig. 20C) with numerous minute tubercles. **Thorax.** Scutum black, shiny, not patterned, moderately covered with dark brown recumbent short hairs interspersed with dark long upstanding hairs on prescutellar area; scutum thinly gray pruinose when illuminated at certain angle of light. Scutellum brownish-black, with dark long hairs. Postnotum brownish-black, shiny, without hairs. Pleural membrane bare. Katepisternum longer than deep, and bare. **Legs.** Foreleg: coxa yellowish-white; trochanter light brown except base of posterior surface yellowish-white; femur light brown except base yellow and apical cap medium brown; tibia light to medium brown except outer portion (except basal and apical tip)

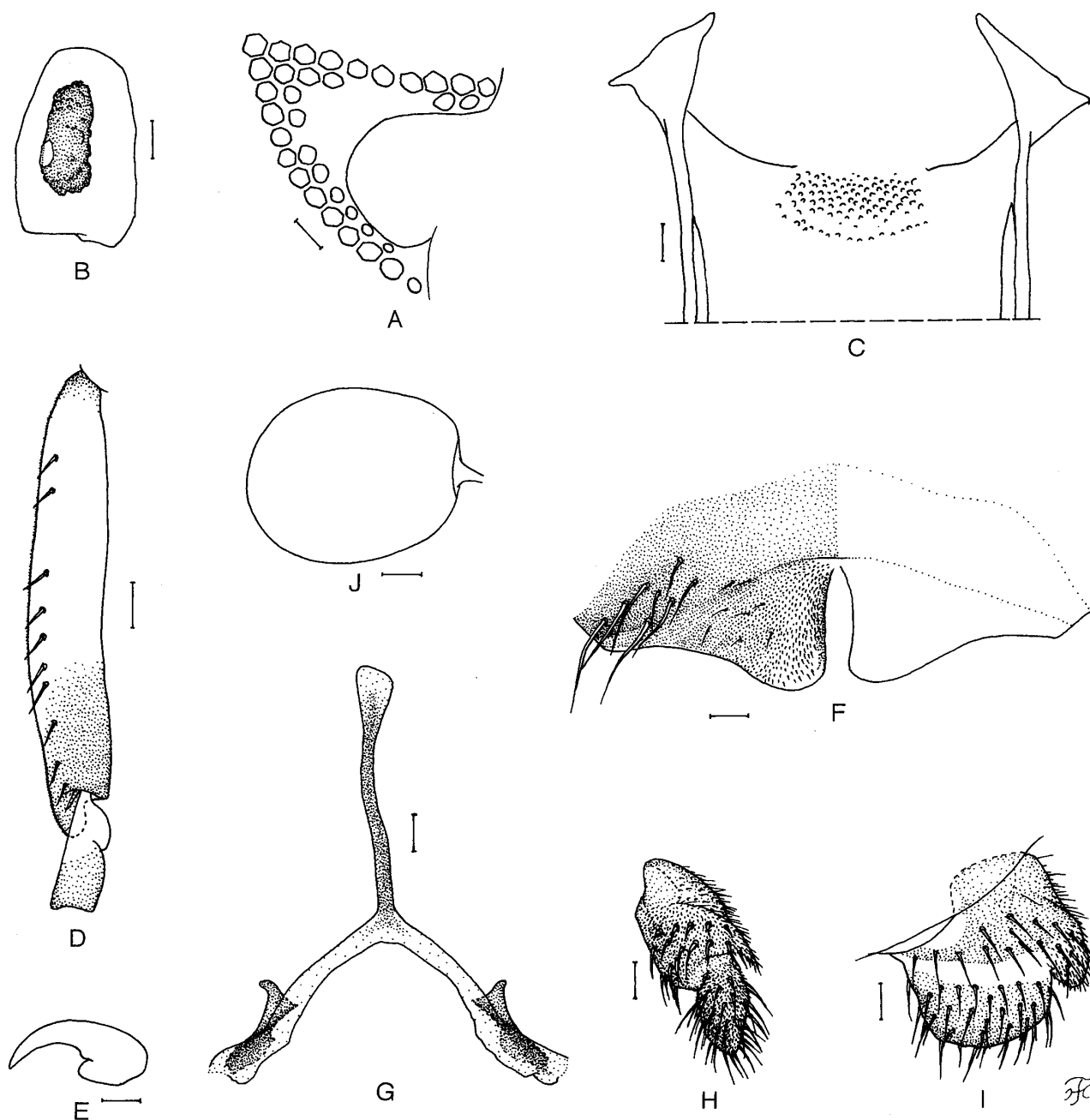


Fig. 20. Female of *Simulium* (*Simulium*) *rangjungense* sp. nov. A, fronto-ocular area (right side; front view); B, 3rd segment of maxillary palp with sensory vesicle (left side; front view); C, upper portion of cibarium; D, hind basitarsus and 2nd tarsal segment (left side; outer view); E, tarsal claw; F, 8th sternite and ovipositor valves *in situ*; G, genital fork; H and I, paraproct and cercus (right side; H, ventral view; I, lateral view); J, spermatheca. Scale bars. 0.05 mm for D; 0.02 mm for A, B and F–J; 0.01 mm for C and E.

widely white and white sheeny when illuminated at certain angle of light; tarsus brownish-black, with thick dorsal hair crest; basitarsus much dilated, 4.67 times as long as its greatest width. Midleg: coxa brownish-black; trochanter light brown except base lighter; femur medium brown; tibia medium to dark brown except base narrowly yellowish-

white; tibia grayish sheeny on posterior surface when illuminated at certain angle of light; basitarsus yellowish-white except apical tip medium brown; rest of tarsal segments medium brown except basal 1/3 of 2nd segment yellowish-white. Hind leg: coxa medium brown; trochanter yellow; femur medium brown with base whitish-yellow and apical cap

dark brown; tibia dark brown with base whitish-yellow; tibia grayish sheeny on posterior surface when illuminated at certain angle of light; tarsus medium brown except basal 2/3 of basitarsus and basal 1/2 of 2nd segment yellowish-white; basitarsus (Fig. 20D) parallel-sided, 5.77 times as long as its width, 0.72 and 0.59 times as wide as greatest widths of hind tibia and femur, respectively; calcipala short, nearly as long as its width at base, and 0.43 times as long as width of basitarsus; pedisulcus distinct. All tarsal claws with very minute swelling basally appearing vestigial tooth (Fig. 20E). **Wing.** Length 1.8 mm; costa with dark spinules and hairs; subcosta haired except apical 1/2 bare; basal section of vein R bare; R_1 with dark spinules and hairs; R_2 with hairs; hair tuft on stem vein dark brown; basal cell absent. **Abdomen.** Basal scale brownish-black with fringe of dark hairs. Dorsal surface of abdomen blackish-brown to black, with dark hairs; segment 2 with broad silvery iridescent transverse band; tergites 6–8 shiny. Ventral surface of abdomen brownish-black; segment 7 with pair of weakly developed sternal plates. **Genitalia.** Sternite 8 (Fig. 20F) well sclerotized, bare medially but with 9 or 10 dark medium-long stout hairs and 2 pale slender short hairs laterally on each side; ovipositor valves (Fig. 20F) tongue-like, rounded posteromedially, membranous, covered with 6 slender short hairs as well as numerous microsetae except narrow portion on posteromedian corner bare; inner margins slightly concave, narrowly sclerotized, and moderately separated from each other. Genital fork (Fig. 20G) of inverted-Y form, with well sclerotized stem having somewhat dilated apex; arms of moderate width, each with strongly sclerotized projection directed anterodorsally. Paraproct in ventral view (Fig. 20H) much longer than wide, with narrowly depressed along anteromedial margin; paraproct in lateral view (Fig. 20I) somewhat protruding ventrally beyond cercus, with anteroventral margin slightly concave medially, and covered with 17 or 18 short and medium-long hairs. Cercus in lateral view (Fig. 20I) rounded posteriorly, 0.58 times as long as its greatest width, moderately covered with short and medium-long hairs. Spermatheca (Fig. 20J) nearly ovoid, 1.16 times as long as greatest width, well sclerotized except small area around juncture with duct unsclerotized, with no definite reticulate surface pattern, with

minute internal setae; accessory ducts subequal in thickness to each other and slightly thicker than major duct.

Male. Body length 2.2 mm. **Head.** Width slightly wider than thorax. Upper eye consisting of large facets in 16 vertical columns and in 17 horizontal rows. Clypeus dark brown, silvery iridescent when illuminated, sparsely covered with dark long stout hairs along lateral and lower margins (medial portion widely bare). Antenna composed of scape, pedicel and 9 flagellomeres, medium brown except scape and base of pedicel and base of 1st flagellomere yellow in dorsal or posterior view (though scape, most of pedicel and basal 1/2 of 1st flagellomere yellow in ventral or anterior view); 1st flagellomere elongate, 1.81 times as long as 2nd one. Maxillary palp composed of 5 segments with proportional lengths of 3rd, 4th, and 5th segments 1.0 : 1.2–1.3 : 2.7–2.8; 3rd segment (Fig. 21A) widened apically; sensory vesicle small, nearly globular, 0.18–0.21 times as long as 3rd segment, and with very small opening. **Thorax.** Scutum black, with white pruinose pattern composed of anterolateral pair of large triangular spots with pointed apex and large transverse spot entirely covering prescutellar area, which is not contiguous to anterolateral spots (Fig. 21B, C); these pruinose areas silvery iridescent when illuminated at certain angles of light; scutum uniformly covered with copper-colored recumbent short hairs (in lights these hairs apparently yellow) interspersed with dark brown similar short hairs on anterior surface and dark brown long upright hairs on prescutellar area. Scutellum dark brown, shiny, white pruinose when illuminated at certain angle of light, with several dark upright dark hairs. Postnotum brownish-black, shiny, white pruinose when illuminated at certain angle of light and bare. Pleural membrane and katapisternum as in female. **Legs.** Foreleg: coxa whitish-yellow; trochanter light brown except base whitish-yellow; femur light brown with apical cap medium brown; tibia medium brown to brownish-black with outer portion (except apical and basal tip) white and white sheeny when illuminated at certain angle of light; tarsus brownish-black, with short dorsal hair crest; basitarsus dilated, 5.51 times as long as its greatest width. Midleg: coxa dark brown with posterior surface brownish-black; trochanter medium brown with base yellowish;

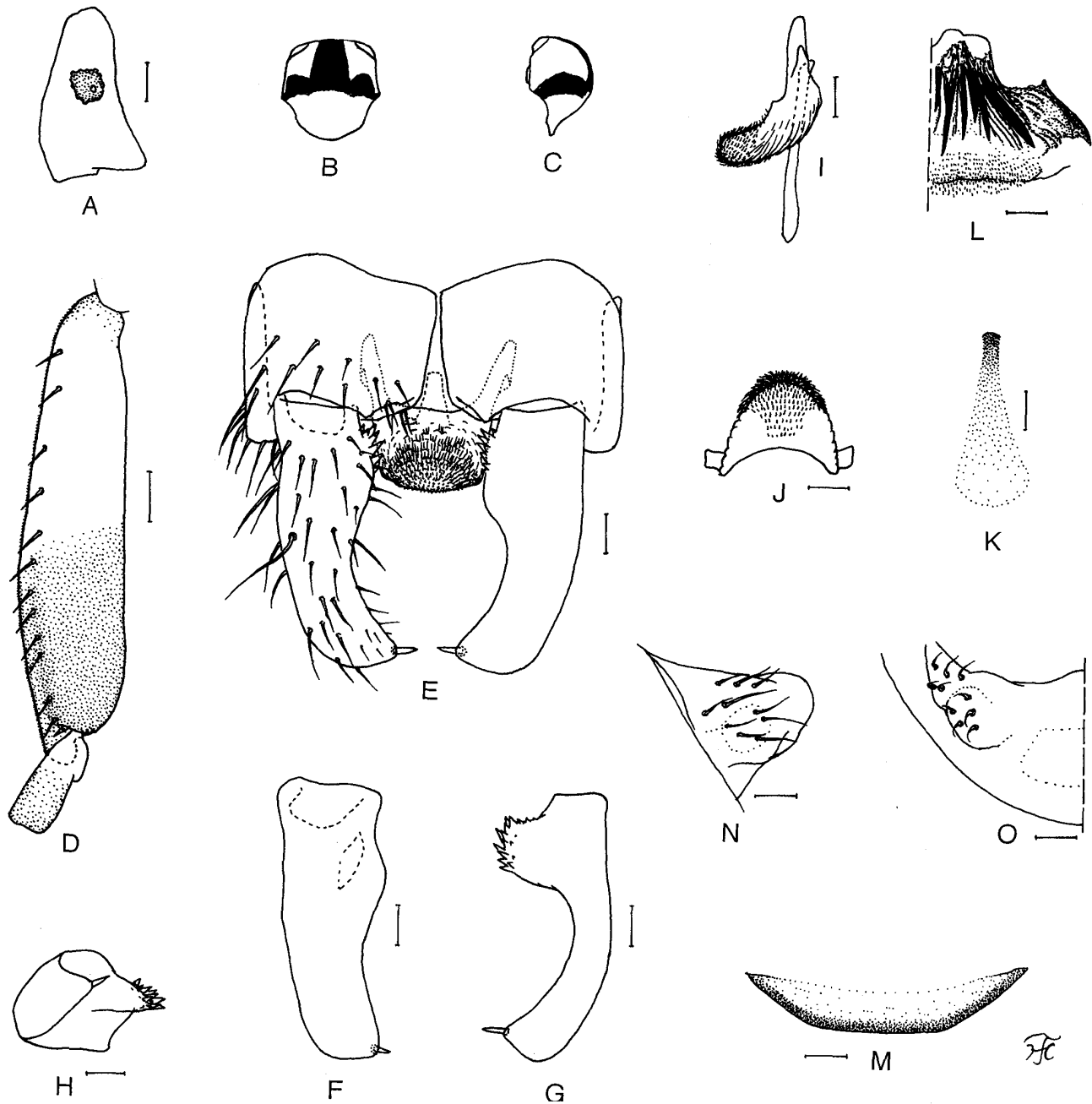


Fig. 21. Male of *Simulium* (*Simulium*) *rangjungense* sp. nov. A, 3rd segment of maxillary palp with sensory vesicle (right side; front view); B and C, thorax (B, dorsal view; C, lateral view); D, hind basitarsus and 2nd tarsal segment (left side; outer view); E, coxites, styles, ventral plate and median sclerite *in situ* (ventral view); F-H, style (F, right side and ventrolateral view; G, left side and medial view; H, right side and end view); I, ventral plate and median sclerite *in situ* (lateral view); J, ventral plate (end view); K, median sclerite (ventral view); L, paramere and aedeagal membrane (left side; end view); M, dorsal plate; N and O, 10th abdominal segment and cercus *in situ* (right side; N, lateral view; O, end view). Scale bars. 0.05 mm for D; 0.02 mm for A and E-O.

femur medium brown with apical cap dark brown; tibia medium to dark brown with extreme base yellow; basitarsus whitish-yellow except apical tip light brown; rest of tarsal segments light brown except basal 1/2 of 2nd segment and base of 3rd segment whitish-yellow. Hind leg: coxa brownish-black; tro-

chanter dark yellow; femur medium brown with apical cap dark brown and extreme base dark yellow; tibia dark with extreme base whitish-yellow; tarsus light to medium brown except little more than basal 1/2 of basitarsus and basal 1/2 of 2nd segment yellowish-white; hind basitarsus (Fig. 21D) much enlarged,

wedge-shaped, widened from base to little beyond basal $1/2$, then nearly parallel-sided, and slightly narrowed apically; basitarsus 4.29 times as long as its greatest width, 0.79 times and 0.81 times as wide as greatest widths of hind tibia and femur, respectively; calcipala small, slightly shorter than its width at base, and 0.35 times as wide as greatest width of basitarsus; pedisulcus well marked on 2nd tarsal segment. **Wing.** Length 2.0 mm; other characters as in female except subcosta bare. **Abdomen.** Basal scale medium brown, with dark long hairs. Dorsal surface of abdomen brownish-black to black, with dark hairs; segments 2 and 5–7 each with pair of silvery iridescent areas dorsolaterally, those on segment 2 connected broadly to each other in middle. **Genitalia.** Coxite in ventral view (Fig. 21E) nearly quadrate. Style elongate in ventral view (Fig. 21E), 1.47 times as long as coxite, narrowed from basal $1/3$ to little beyond midpoint, then nearly parallel-sided up to apex though gently curved inward, and with terminal spine; style in ventrolateral view (Fig. 21F) with inner margin roughly S-shaped; style in medial and end views (Fig. 21G, H) with basal protuberance directed dorsomedially, bearing about 10 spinules on its surface. Ventral plate in ventral view (Fig. 21E) with base nearly quadrate in shape, having ventrally-produced hairy process with posterior margin slightly convex and basal arms slightly diverging from each other; ventral plate in lateral view (Fig. 21I) with serrated posterior margin; ventral plate in end view (Fig. 21J) with round hairy process produced ventrally, and lateral margins weakly serrated on basal $2/3$. Median sclerite (Fig. 21K) moderately sclerotized basally, plate-like, widened toward apex. Paramere (Fig. 21L) with 5 or 6 long and medium-long hooks. Aedeagal membrane (Fig. 21L) moderately covered with minute spines; dorsal plate (Fig. 21M) well sclerotized basally. Abdominal segment 10 (Fig. 21N, O) with 5 distinct hairs on each lateral surface. Cercus (Fig. 21N, O) small, not so raised, with 5 or 6 hairs.

Pupa. Body length (excluding gill filaments) 2.5 mm. **Head.** Integument yellowish-brown; frons moderately covered with round tubercles of medium-size (Fig. 22A), lateral surface of face moderately covered with very small tubercles except area along posterodorsal margin with tubercles of medium-size (Fig. 22B) which are though much smaller than those on frons; antennal sheath sparsely covered with round tubercles (Fig. 22C); frons with 2 pairs of simple medium-long trichomes of slightly different length (Fig. 22D) on each side; face with pair of simple long trichomes (Fig. 22E) on each side, which are slightly longer than those of frons. **Thorax.** Integument dark yellow to yellowish-brown, moderately covered with round tubercles; thorax on each side with 1 simple slender very short trichome mediodorsally (Fig. 22F), 2 simple slender trichomes (1 medium-long, 1 very short) anterolaterally (Fig. 22G), 1 simple medium-long trichome posterolaterally (Fig. 22H), and 3 simple trichomes (1 medium-long, 2 short) ventrolaterally (Fig. 22I). Gill (Fig. 22J) with 6 slender thread-like filaments arranged in 3 pairs with very short stalk; filaments subequal in length to one another (1.3–1.5 mm long) except ventral filament of ventral pair apparently shortest (1.1 mm long); relative thickness of all filaments 1.1 : 1.0 : 1.1 : 1.0 : 1.1 : 0.8 from dorsal to ventral; all filaments light brown, tapered toward apex, directed forward and slightly downward, with well marked annular ridges and furrows throughout their length forming reticulate surface patterns, and densely covered with minute tubercles. **Abdomen.** Dorsally, segment 1 pale yellowish, with 1 simple slender medium-long seta (Fig. 22K) on each side; segment 2 nearly transparent, with 1 simple medium-long seta and 5 simple spinous very short setae (Fig. 22L) on each side; segments 3 and 4 each with 4 hooked spines along posterior margin and 1 very short spinous seta on each side; segments 7–9 each with spine-combs in transverse row, together with comb-like groups of minute spines on

Fig. 22. Pupa of *Simulium* (*Simulium*) *rangjungense* sp. nov. A, frons and part of face; B, lateral portion of face; C, antennal sheath; D, frontal trichomes; E, facial trichome; F–I, thoracic trichomes (F, mediodorsal; G, anterolateral; H, posterolateral; I, ventrolateral); J, gill filaments (right side; lateral view); K, medium-long seta on dorsal surface of abdominal segment 1; L, medium-long seta and short seta on dorsal surface of abdominal segment 2. Pupa of *S. (S.) tani*. M, frons and part of face; N, lateral portion of face; O, mediodorsal trichomes on thorax; P, anterolateral trichomes on thorax. Scale bars. 0.1 mm for J; 0.02 mm for A–C, M and N; 0.01 mm for D–I, K, L, O and P.



each side; segment 9 with small cone-shaped terminal hooks. Ventrally, segment 4 with 1 simple hook and 1 simple short seta submedially on each side; segment 5 with pair of bifid hooks submedially on each side; segments 6 and 7 each with pair of bifid inner and simple outer hooks widely spaced on each side. Grapnel-like hooklets absent. **Cocoon.** Simple, wall-pocket-shaped, moderately woven, with anterior margin not strongly woven, not extending ventrolaterally; individual threads visible; 2.6 mm long by 1.0 mm wide.

Mature larva. Unknown.

TYPE SPECIMENS. Holotype female (with its pupal exuviae and cocoon), reared from a pupa collected from a moderately flowing irrigation canal (width 30 cm, depth 10 cm, water temperature 24°C, exposed to sun, altitude 1,051 m) in a sparsely forested area in Rangjung, Trashigang, Bhutan, 29. VIII. 2007. Paratype: 1 male (reared from pupa), same data as those of the holotype.

ECOLOGICAL NOTES. The pupae of this new species were collected on a slender root of trailing grass, together with immature larvae of two unidentified species, one of *Gomphostilbia* and the other, the *variegatum* species-group of *Simulium*.

ETYMOLOGY. The species name *rangjungense* refers to the locality name, Rangjung, where this new species was collected.

REMARKS. This new species is assigned to the *tuberosum* species-group redefined by Takaoka and Davies (1996), and is very similar to *S. (S.) tani* Takaoka and Davies, originally described from Peninsular Malaysia (Takaoka and Davies, 1995). However, this new species is barely distinguished from the latter in the male by the scutal color pattern, in which the non-pruinose black transverse band is much narrower than the anterolateral white pruinose spot when viewed laterally (Fig. 21B, C), and in the pupa by the outer filaments of all three pairs of almost the

same thickness (Fig. 22J) (c.f., slightly becoming thinner from dorsal to ventral in *S. (S.) tani*), the frontal and facial integuments sparsely covered with small tubercles (Fig. 22A, B) (c.f., moderately in *S. (S.) tani*, Fig. 22M, N), the very short mediodorsal trichome (Fig. 22F) on each side, and two anterolateral trichomes, of which one is much shorter than the counter one (Fig. 22G) on each side (c.f., in *S. (S.) tani*, mediodorsal and anterolateral trichomes are all short and subequal in length to each other, Fig. 22O, P). The female cercus of this new species (Fig. 20I) is apparently longer than that of *S. (S.) tani* illustrated in the original description but some other female specimens collected from Peninsular Malaysia and examined in this study show the cercus which is similar in shape and size to that of this new species. Examination of some male specimens of *S. (S.) tani* from Peninsular Malaysia also show intraspecific variation in the size of the male hind basitarsus, i.e., the length ratio against its greatest width varying from 3.5 (as noted in the original description) to 4.2 (close to 4.28 in this new species).

This new species is also similar to *S. (S.) nitidithorax* Puri described from India (1932a) but differs from the latter species by the male scutum with an anterolateral pair of white pruinose spots which are separated from the white pruinose spot on the prescutellar area (Fig. 21C) and the pupal gill filaments arranged in three pairs with a short stalk (Fig. 22J) (c.f., anterolateral pair of white pruinose spots are contiguous with the white pruinose spot on the prescutellar area and the pupal gill filaments are arranged in three sessile pairs in *S. (S.) nitidithorax* according to the original description).

***Simulium (Simulium) pradyai*
Takaoka sp. nov.**

DESCRIPTION. Female. Body length 2.2 mm. **Head.** Narrower than width of thorax. Frons brownish-black, shiny, with several dark

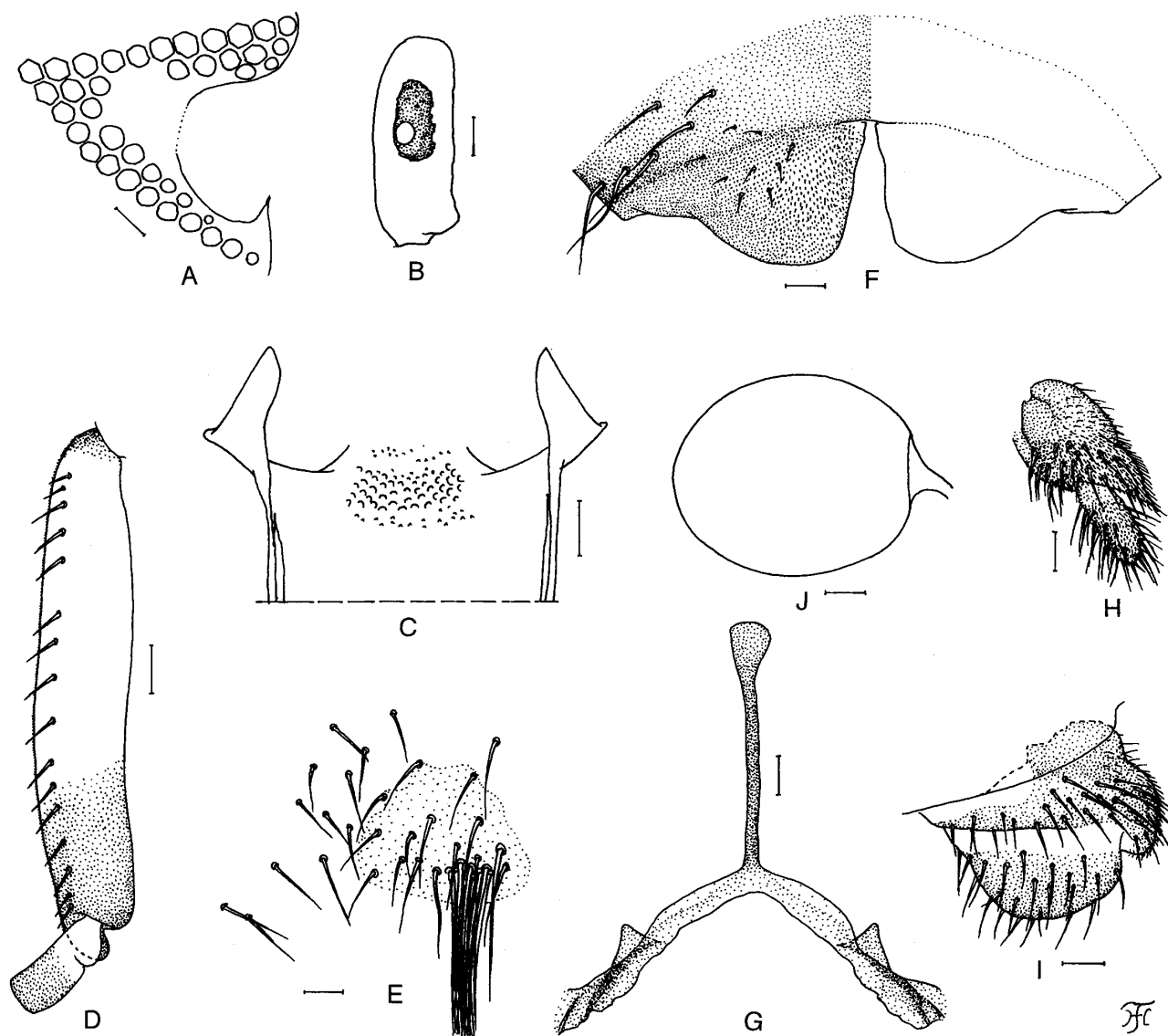


Fig. 23. Female of *Simulium* (*Simulium*) *pradyai* sp. nov. A, fronto-ocular area (right side; front view); B, 3rd segment of maxillary palp with sensory vesicle (right side; front view); C, upper portion of cibarium; D, hind basitarsus and 2nd tarsal segment (left side; outer view); E, 7th sternite with clustered long hairs and scattered shorter hairs (right side); F, 8th sternite and ovipositor valves *in situ*; G, genital fork; H and I, paraproct and cercus (right side; H, ventral view; I, lateral view); J, spermatheca. Scale bars. 0.05 mm for D; 0.02 mm for A–C and E–J.

stout hairs along lateral margins and near lower margin; frontal ratio 1.30:1.00:1.16; frons-head ratio 1.00:3.92. Fronto-ocular area (Fig. 23A) moderately developed, directed laterally and with round tip. Clypeus brownish-black, shiny, covered with dark hairs along both lateral margins and sparsely covered with similar hairs on lower 1/3 (most of central area on upper 2/3 bare). Labrum 0.70 times as long as clypeus. Antenna composed of scape, pedicel and 9 flagellomeres, dark brown except scape, pedicel and basal minute of 1st flagellomere yellow. Maxillary palp medium brown, composed of 5 segments, proportional lengths

of 3rd, 4th, and 5th segments 1.00:1.03:2.30; 3rd segment (Fig. 23B) moderately enlarged; sensory vesicle (Fig. 23B) elongate, 0.40 times as long as 3rd segment, with medium-sized round opening. Maxillary lacinia with 14 or 15 inner and 17 or 18 outer teeth. Mandible with 33 inner and 14 outer teeth. Cibarium (Fig. 23C) with about 80 small processes. **Thorax.** Scutum brownish-black to black, thinly grayish pruinose, shiny, moderately covered with whitish-yellow recumbent short hairs interspersed with dark brown long upright hairs on prescutellar area. Scutellum dark brown, with dark brown long upright hairs and whitish-

yellow short hairs. Postnotum dark brown to brownish-black, grayish pruinose, shiny, and bare. Pleural membrane bare. Katepisternum longer than deep, dark brown to brownish-black, bare, grayish pruinose and shiny when illuminated. **Legs.** Foreleg: coxa whitish-yellow; trochanter whitish-yellow with parts of dorsal and ventral surface light brown; femur light to dark brown except base of inner surface yellow; tibia yellowish-white except apical $1/5$ dark brown; outer surface widely white sheeny when illuminated at certain angle of light; tarsus brownish-black, with thick dorsal crest of short hairs; basitarsus moderately dilated, 5.36 times as long as greatest width. Midleg: coxa dark brown with posterolateral surface brownish-black; trochanter medium brown with base yellow; femur medium to dark brown; tibia light to dark brown with basal $2/5$ yellowish-white; tibia white sheeny widely on posterior surface when illuminated at certain angle of light; tarsus medium brown except basal $1/2$ of basitarsus yellowish-white. Hind leg: coxa dark brown to brownish-black; trochanter yellow; femur medium to dark brown with base yellow; tibia medium to dark brown with little more than basal $2/5$ yellowish-white; tibia white sheeny widely on posterior surface when illuminated at certain angle of light; tarsus medium brown except basal $2/3$ of basitarsus and basal $1/2$ of 2nd segment yellowish-white; basitarsus (Fig. 23D) nearly parallel-sided, 5.60 times as long as its greatest width, 0.83 and 0.73 times as wide as greatest widths of hind tibia and femur, respectively; calcipala slightly shorter than width at base, and 0.40 times as wide as greatest width of basitarsus; pedisulcus distinct; all tarsal claws simple, without tooth. **Wing.** Length 2.0 mm. Costa with dark spinules and hairs. Subcosta haired except near apex bare. Basal section of vein R bare; R_1 with spinules and hairs; R_2 with hairs only. Hairs at base of stem vein dark brown. Basal cell absent. **Abdomen.** Basal scale brownish-black, with fringe of yellow hairs. Dorsal surface of abdominal segments dark brown to brownish-black, with dark hairs; 2nd segment with pair of large silvery iridescent dorsolateral spots broadly connected in middle to each other; tergites 6–9 shiny. Ventral surface of abdominal segment 7 (Fig. 23E) with pair of round sternal plates each having 9–15 dark brown long hairs in cluster and 10–13 dark medium-long hairs;

hairs in cluster subequal in length to one another and twice as long as or little longer than surrounding scattered hairs. **Genitalia.** Sternite 8 (Fig. 23F) well sclerotized, smooth medially, covered with 3–6 long and medium-long stout hairs and few short fine hairs on each side. Ovipositor valves (Fig. 23F) tongue-like, rounded posteromedially, membranous except inner margins weakly sclerotized, densely covered with microsetae together with 5 or 6 short fine hairs; inner margins slightly sinuous and diverged posteriorly from each other. Genital fork (Fig. 23G) of inverted-Y form; stem slender, well sclerotized and with somewhat inflated apex; arms of moderate width, each with strongly-sclerotized lateral ridge having distinct projection directed forward. Paraproct in ventral view (Fig. 23H) triangular, tapered posteromedially, moderately concave anterolaterally, and with strongly sclerotized anteromedial surface; paraproct in lateral view (Fig. 23I) slightly produced ventrally, 1.71 times as wide as its length, covered with 24–28 medium-long stout hairs and numerous short fine hairs on lateral and ventral surface. Cercus in lateral view (Fig. 23I) short, rounded posteriorly, 0.60 times as long as its greatest width, and covered with numerous medium-long and short stout hairs. Spermatheca (Fig. 23J) ellipsoidal, 1.15 times as long as wide, well sclerotized except duct and narrow area of juncture with duct unsclerotized, without reticulate surface patterns; minute internal setae present; both accessory ducts subequal in diameter to each other, and also to that of main duct.

Pupa. Body length (excluding gill filaments) 2.5 mm. **Head.** Integument light yellowish-brown, almost smooth except small area near bases of facial trichomes with several round tubercles (Fig. 24A); antennal sheath also smooth: frons with 2 simple very long trichomes arising close together (Fig. 24B) on each side; face with 1 simple very long trichome (Fig. 24C) on each side. **Thorax.** Integument light yellowish-brown, almost bare except lateral surface of anterior $1/2$ very sparsely covered with small round tubercles (Fig. 24D) and dorsal surface of posterior $1/2$ moderately covered with small cone-shaped and round tubercles; thorax with 2 simple very long trichomes mediadorsally (Fig. 24E), 2 simple trichomes (1 very long, 1 long) anterolaterally (Fig. 24F), 1 simple long trichome

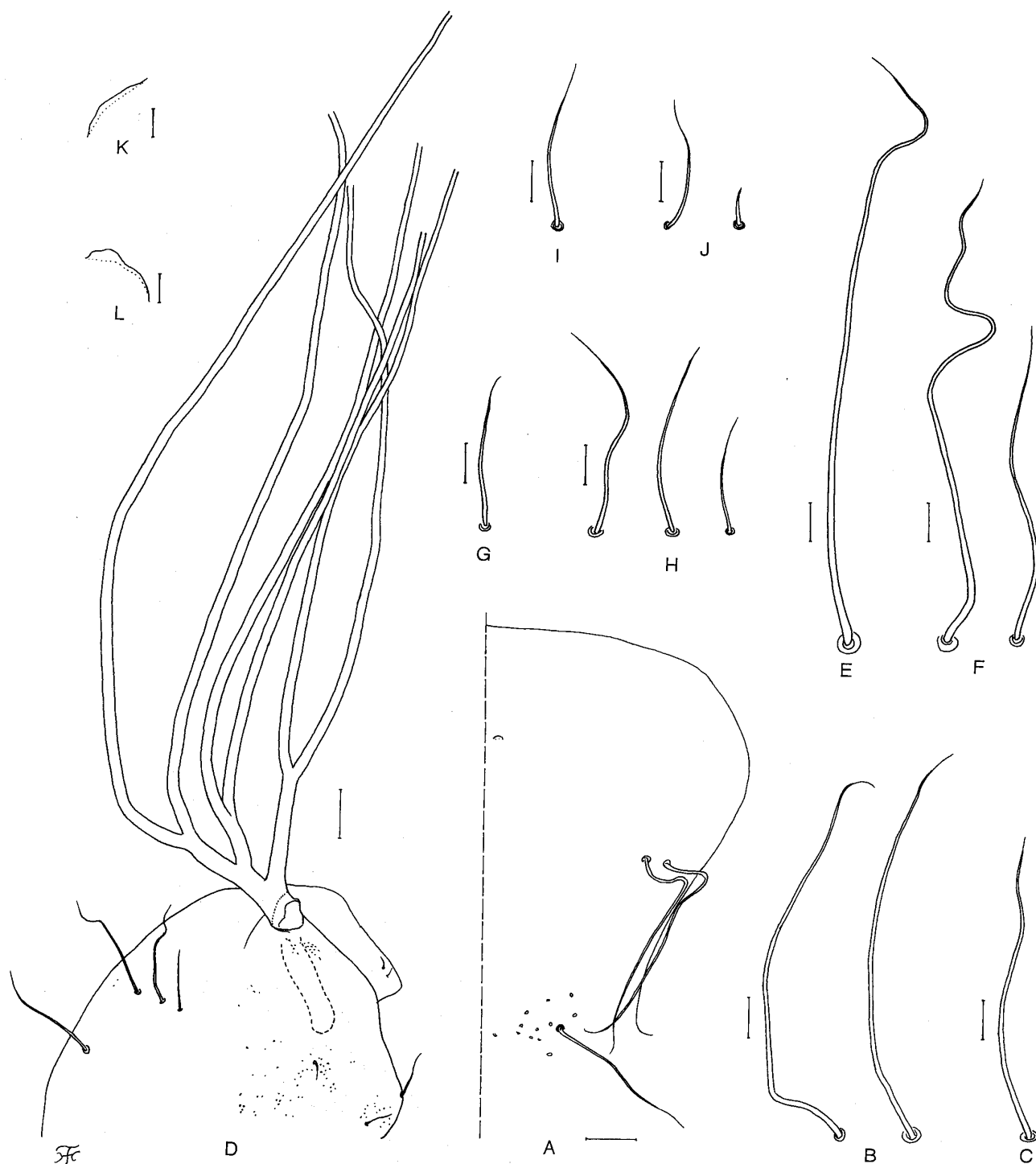


Fig. 24. Pupa of *Simulium* (*Simulium*) *pradyai* sp. nov. A, frons and part of face with trichomes; B, frontal trichomes; C, facial trichome; D, anterior half of thorax with trichomes and gill filaments (all tips lost) (right side; lateral view); E-H, thoracic trichomes (E, mediodorsal; F, anterolateral; G, posterolateral; H, ventrolateral); I, medium-long seta on dorsal surface of abdominal segment 1; J, medium-long seta and short seta on dorsal surface of abdominal segment 2; K and L, weakly developed terminal hook (end view; K, left side; L, right side). Scale bars. 0.1 mm for D; 0.05 mm for A; 0.02 mm for B, C and E-J; 0.01 mm for K and L.

posterolaterally (Fig. 24G), and 3 simple trichomes (2 long, 1 medium-long) ventrolaterally (Fig. 24H) on each side. Gill (Fig. 24D) with 6 slender thread-like filaments arranged in (2+2)

+2 filaments from dorsal to ventral; common basal stalk very short, with transparent somewhat swollen organ ventrally; dorsal and middle pairs with medium-long stalks arising

from short stalk, ventral pair with long stalk, which is as thick as stalk of middle pair and slightly thinner than stalk of dorsal pair; all filaments medium brown, directed forward, lying nearly in vertical plane, probably decreasing in length from dorsal to ventral (exact lengths of all filaments not known because all tips were cut off and lost) with longest dorsal filament probably little more than 2.0 mm); relative thickness of all filaments from dorsal to ventral 1.00 : 1.00 : 0.89 : 0.89 : 0.89 : 0.89 (when basal portions were compared) or 1.00 : 1.00 : 0.88 : 0.75 : 0.75 : 0.75 (when middle portions were compared); stalks of dorsal and ventral pairs diverged basally at angle of about 60 degrees; cuticular surface with distinct annular ridges and furrows throughout their length, covered with minute tubercles of different sizes, relatively larger ones on ridges and smaller ones on interridge spaces. **Abdomen.** Dorsally, segment 1 with 1 simple slender medium-long seta (Fig. 24I) on each side; segment 2 with 1 simple slender medium-long seta and 5 simple very short spinous setae (Fig. 24J) on each side; segments 3 and 4 each with 4 simple hooked spines and 1 simple very short seta on each side; segments 5 and 6 without spine-combs; segments 7–9 each with spine-combs and comb-like groups of minute spines on each side; segment 9 with pair of weakly developed terminal hooks (Fig. 24K, L). Ventrally, segment 4 with 1 simple hooklet and few simple short setae on each side; segment 5 with pair of bifid hooks submedially and 1 simple short seta on each side; segments 6 and 7 each with pair of bifid inner and simple outer hooks widely spaced and 1 simple short seta on each side. Grapnel-like hooklets absent. **Cocoon.** Wall-pocket-shaped, moderately woven, often with very small open spaces anteriorly, not extending ventrolaterally; individual threads visible; 2.5 mm long by 1.2 mm wide.

Male and mature larva. Unknown.

TYPE SPECIMENS. Holotype female (with its associated pupal exuviae and cocoon), reared from a pupa collected from a moderately-flowing stream (width 2 m, depth 10–20 cm, water temperature 22°C, exposed to sun, altitude 2,570 m; 27°32'20"N, 90°48'26"E) in a sparsely forested area, Dungmithang, Bumthang, Bhutan, 5. IX. 2007. Paratypes: 3 females,

all reared from pupae, same data and date as those of the holotype; 1 pharate female, collected from a slow-flowing stream (width about 1 m, depth 10 cm, water temperature below 5°C, exposed to sun, altitude 3,720 m; 27°23'54"N, 90°59'39"E) in a densely forested area, Thrimshingla, Mongar, Bhutan, 4. IX. 2007.

ECOLOGICAL NOTES. The pupae of this new species were collected from grass stalks in the water. The associated species were *S. (M.) nemorivagum*, *S. (N.) bumthangense* and *S. (N.) thrimshinglaense* sp. nov.

ETYMOLOGY. The species name *pradyai* is in honor of Dr. Pradya Somboon, Department of Parasitology, Faculty of Medicine, Chiang Mai University, Thailand, who collected all the samples treated in this study.

REMARKS. This new species is assigned to the *tuberosum* species-group redefined by Takaoka and Davies (1996), and seems to be closely related to *S. (S.) rufibasis* Brunetti, and *S. (S.) ramosum* Puri, both originally described from India (Puri, 1932a), and *S. (S.) doipuiense* Takaoka and Choochote, *S. (S.) manooni* Takaoka and Choochote, *S. (S.) setsukoe* Takaoka and Choochote, and *S. (S.) weji* Takaoka, all described from Thailand (Takaoka, 2001; Takaoka and Choochote, 2004, 2005) in that the female has a pair of clustered long and stout hairs on the seventh sternite (Fig. 23E). However, this new species is easily distinguished in the pupa from all these known species (except *S. (S.) setsukoe* of which the pupa is not known yet) by the frons and the anterior half of the thorax which are almost smooth (Fig. 24A, D), as well as the gill filaments arranged in three pairs with medium-long or long stalks (Fig. 24D). The female of this new species differs from that of *S. (S.) setsukoe* by the clustered stout hairs on the seventh sternite which are much longer than those on the surrounding area (Fig. 23E) (c.f., clustered stout hairs are

short, nearly as long as those on the surrounding area in *S. (S.) setsukoae*).

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